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Page 218, line 83, for " 1864 " read " 1869."

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# The Meteorological Magazine



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## International Days\*

The regular issue of the *blanc Hefte* which carried the results of the international days for the Commission for the Exploration of the Upper Air under the presidency of Hugo Hergesell Director of the Meteorological Institute of Strassburg was interrupted by the war.

After the war Professor V. Bjerknes became president, and at a meeting at Bergen in 1921 international enterprise was resumed and questions of units and other technical matters were discussed. Shortly afterwards I learned by post that I had been elected president and in 1925 with the material for 1923 in hand a meeting was held in London to settle details of form.

With the generous assistance of a grant from the meteorological section of the Union Géographique et Géophysique Internationale the printed volume in four parts was presented at a meeting at Leipzig in 1927. It included a list of stations and data synoptic pressure charts of the world for the international days 36 in all tables of data in the prescribed form with units.

\**Ergebnisse der aerologischen Messungen 1922 Internationale Kommission für die Erforschung der freien Atmosphäre Berlin 1930 1 784 pp Herausgegeben von dem Präsidenten G. H. Rat Prof. Dr. H. Hergesell*

*Comptes Rendus les jours internationaux 1924 Commission internationale de la haute atmosphère London 1932 Première partie 161 pp Tableaux des sondages réduits Cartes synoptiques Deuxième partie 24 pp Photo de laphigrammes*



strongly reminiscent of "Dynamic Meteorology and Hydrography"; and reproductions of entropy-temperature diagrams of the soundings by balloon, which then received the name of tephigrams. The volume was placed on sale at £2 per copy.

The Leipzig meeting authorised an appeal for promises of subscription to repeat the effort for the international days of 1924 at a price not exceeding £3 per copy. Dr. Hergesell was reappointed president. The arrangements for 1925 and beyond were entrusted to his charge.

The material for 1924 was made ready during 1928, but had to wait for an arrangement about costs which was finally achieved as the result of a resolution of a meeting of the Commission at Madrid in 1931 and facilitated by the adoption of a method of reproduction of typescript by photography, which is specially economical when observations have to be expressed in complicated tables of figures in irregular rows and columns.

In the meantime the President approached the problem from a similar standpoint and commenced the issue of "blaue Hefte" for the international days of 1925. During 1929, '30 and '31, he issued 784 pages of material in 18 parts, of which one, namely, that for January 24th, 1925, represents the data for a special inquiry, arranged by telegraph, into the features of a notable anticyclone. The others are for April 14th-16th, August 17th-22nd, and December 1st-31st, representing the "international month" for that year. Economy of space is secured by a long table of 29 symbols, a table of *Generalia* for the stations grouped into districts giving geographical co-ordinates and time of ascent, conditions of weather at the surface, particulars of the instruments and apparatus employed, of the greatest height reached and the mode of reaching it. Then a table of geopotential, or geodynamic height, temperature and relative humidity for isobaric surfaces in 100 mb. steps from 1,000 mb., followed by a table of pressure, temperature and humidity for steps of geodynamic height 500, 1,000, 2,000 geodynamic metres, and so on; then a repetition of the same for geometric heights of the same figure, and a table of an indefinite number of steps of height with corresponding pressure, temperature and humidity.

When there are pilot balloons, direction and velocity of the wind are given for heights variously chosen. The method of indicating cloud observations and those at mountain stations need not be particularised.

The issue for 1925, priced at £3, has been followed by a corresponding issue for 1926, covering 1,054 pages in the same style with the same price. The data are entirely numerical; meanwhile the volume for 1924 has appeared priced at £2 5s. per copy: 144 pages of tables in the same form as 1923 with 12 pages of pressure-charts for the 38 international days of that

year. Also with the aid of a special grant from the International Meteorological Organisation there is a separate part of tephigrams for the *ballon-sonde* ascents. Superposed thereon when the information is available are diagrams of the components of the horizontal velocity of the balloons in their flight.

There is some difference of opinion in the highest meteorological circles about the relative merits of diagrams and numerical data for representing the achievements of international effort. Some are of opinion that scientific reality can only be expressed in numbers and with reduction to numbers the original graphs should be understood to make them how to international curiosity. Others on the contrary if they wished to see how things were going in the upper air would sooner turn over twenty pages of diagrams than a hundred pages of numbers which a poet once called mournful. A word may be added in favour of that view because the numerical results for each country are generally given in detail in the publications of the several institutes and the great advantage of collecting the world's observations in one volume is that it emphasises the geographical aspect of the exploration and makes it possible to bring meteorology, geography and chronology on the stage together within sight of the curious student of weather.

Sometime it must be realized that after sixty years of synoptic maps ostensibly for sea level some vertical sections particularly along meridians are necessary for making an effective picture of the atmospheric structure. The volumes of international days give the material at present available for that ideal and perhaps the suggestion which they whisper is that as a sounding balloon works quite creditably with a meteorograph failing only for lack of ventilation a meteorograph might be carried also by an aeroplane and then the daily aero plane from Dakar to Oran from Oran to Paris from Paris to London from London to Iceland from Iceland to Greenland from Greenland to Toronto and from Toronto to Washington and back would give us some interesting information which would be a useful frame for the isolated data of the international days. And then with the motor car suggested by the Italian Ufficio Previsioni as a mobile observatory ascents of *ballon sondes* might be arranged at selected points along the air routes for obtaining sections instead of at fixed stations. The meteorological millennium would become visible in the background of the view.

NARIN SHAW

## The Areas with Light and Heavy Rainfalls

Three years ago we prepared revised figures\* of the average annual rainfall of each five-degree zone of the earth's surface.

\*The zonal distribution of rainfall over the earth. *London, Mon. & Weather Soc.*, 8, No. 28, 1980.

Subsequently, figures were required, for another purpose, of the zonal areas with rainfall below 10 inches a year; and this information was readily derived from the working sheets for the earlier investigation. It seemed desirable to put these results on record, with similar figures for the areas with rainfall between various limits. The figures for the land and sea were computed separately. For most of the land areas the figures are reasonably trustworthy, being derived from good rainfall charts, while much of the area for which satisfactory charts are not available is desert and may be assumed to have a rainfall below 10 inches. For the oceans the charts are far less reliable, and in places are not far removed from guess-work, hence the results for the oceans are given in skeleton form only.

TABLE I.—PERCENTAGE AREAS WITH ANNUAL RAINFALL, BETWEEN SPECIFIED LIMITS.

	0—10in.	10—20in.	20—40in.	40—60in.	60—100in.	Above 100in.
<b>Land</b>						
70°—60°N	48	41	0	2	0	0
60°—50°N	4	62	81	2	1	0
50°—40°N	30	81	92	5	2	0
40°—30°N	84	81	21	11	3	0
30°—20°N	59	6	0	15	11	1
20°—10°N	20	15	28	11	12	5
10°N—0°	1	8	14	27	87	18
0°—10°S	1	2	18	28	48	18
10°—20°S	4	9	85	81	20	1
20°—30°S	85	28	23	9	10	0
30°—40°S	20	20	81	11	8	0
40°—50°S	44	0	17	9	16	5
50°—60°S	7	84	22	15	17	5
70°N—60°S	20	25	22	18	11	9
<b>Ocean</b>						
70°—40°N	5	8	20	27	25	0
40°—10°N	8	17	27	19	25	4
10°N—10°S	8	26	11	10	30	20
10°S—40°S	8	15	32	20	24	1
70°N—40°S	0	18	25	18	20	7

Table I shows the percentage areas between certain limits for each 10-degree zone of the continents and for the north-temperate, sub-tropical and equatorial zones over the oceans. The figures for the land bring out some interesting points, notably the extremely large proportion of the land between 30° and 20°N, which has a rainfall below ten inches and the general heaviness of the rainfall in the equatorial region between 10°N. and 10°S. The storm belt between 50° and 60°N. has a generally moderate rainfall, while between 60° and 70°N. 89 per cent. of the area receives less than 20 inches a year. South of 20°S. the percentage areas with low rainfalls again increase, but beyond 40°S. the land areas are small and the 44 per cent. below ten inches in 40-50°S. lies almost entirely in Patagonia. The data for the oceans are less reliable but serve to bring out

the general moderateness of the amounts, except near the equator.

The figures for the land areas as a whole show that more than a quarter of the whole land surface has a rainfall below ten inches, and more than one-half has a rainfall below 20 inches, while only one-thirtieth exceeds 100 inches. On the other hand less than one-quarter of the sea surface receives less than 20 inches,, and as much as one-fourteenth exceeds 100 inches, though the latter figure especially is very doubtful. The average annual depths of rain over the land and sea have been computed as 25.9 inches and 43.6 inches respectively.

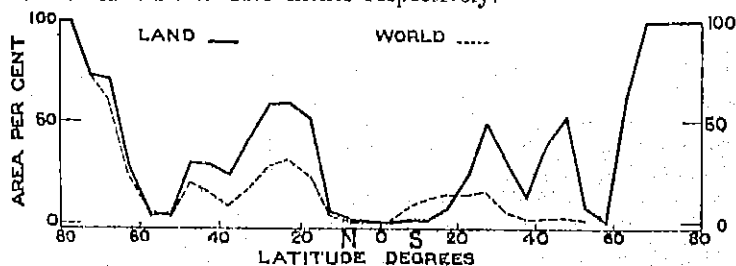


FIG. 1. PERCENTAGE AREAS WITH RAINFALL BELOW 10 INCHES.

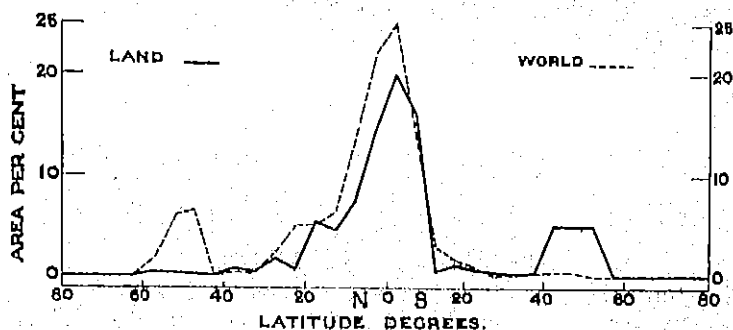


FIG. 2. PERCENTAGE AREAS WITH RAINFALL ABOVE 100 INCHES.

The incidence of rainfall below ten inches in different latitudes is shown graphically in Fig. 1, the full line representing the percentage of land areas and the broken line that of the world as a whole. Apart from the polar regions which probably everywhere receive less than ten inches, there are two main zones of light rainfall, over the land between 15° and 30°N. and between 20° and 35°S. The second maximum in the southern hemisphere, between 40° and 50°S., represents only the narrow dry area of Patagonia previously referred to. The broken line, representing percentage areas over the world as a whole, shows essentially the same features, except that the Patagonian maximum almost entirely disappears and the southern dry area is

shown to extend mainly from  $10^{\circ}$  to  $30^{\circ}$ S., almost symmetrical with that in the northern hemisphere. The secondary maximum in  $40^{\circ}$ - $50^{\circ}$ N. represents mainly the great deserts of Mongolia and Turkestan, while the dip in  $35^{\circ}$ - $40^{\circ}$ N. is due largely to the monsoon rains of Asia.

Fig. 2 shows the percentage areas with rainfall above 100 inches, and is chiefly remarkable for the great equatorial maximum on both curves. In  $0^{\circ}$ - $5^{\circ}$ S. the areas reach 20 per cent. for the land and 25 per cent. for the whole world. The secondary maximum about  $50^{\circ}$ N. is due to the heavy rainfall in the North Atlantic in this stormy latitude, while the secondary maximum in land areas about  $50^{\circ}$ S. results mainly from the heavy rainfall along the coastal ranges of Chile.

During the process of calculation figures were obtained for the average rainfall of the British Isles in each degree of latitude, which have some interest, and these are given in table II. The most noteworthy points shown by this table are the pronounced maximum between  $56^{\circ}$  and  $57^{\circ}$ N., which include most of the Scottish Highlands, and the minimum between  $52^{\circ}$  and  $53^{\circ}$ N., which covers the widest and flattest part of England and Wales.

TABLE II.—AVERAGE RAINFALL OF THE BRITISH ISLES IN EACH DEGREE OF LATITUDE.

	$50^{\circ}$ - $55^{\circ}$	$55^{\circ}$ - $56^{\circ}$	$56^{\circ}$ - $57^{\circ}$	$57^{\circ}$ - $58^{\circ}$	$58^{\circ}$ - $59^{\circ}$	$59^{\circ}$ - $60^{\circ}$	$60^{\circ}$ - $61^{\circ}$	$61^{\circ}$ - $62^{\circ}$	$62^{\circ}$ - $63^{\circ}$
	in.	in.	in.	in.	in.	in.	in.	in.	in.
Great Britain	47.6	55.5	61.4	43.8	48.6	34.7	32.8	34.1	40.2
Ireland				45.5	44.8	40.7	43.0	62.0	

C. E. P. BROOKS.

THESSA M. HUNT.

## OFFICIAL PUBLICATIONS

The following publications have recently been issued:—

GEOPHYSICAL MEMOIRS No. 56. *Some upper-air observations over Lower Egypt.* By S. P. Peters, B.Sc., A.Inst.P.

Owing to the increasing importance of lower Egypt as a centre of convergence of air routes traversing the continents of Europe, Asia and Africa, any addition to our limited knowledge of meteorological conditions in the upper air of this region is to be regarded as welcome. An important contribution to the subject is to be found in this *Memoir*, which records and discusses a notable series of observations made in 1925 and 1926 by means of aeroplane ascents from the Royal Air Force aerodrome at Abu Sueir. The unique feature of the investigation is the fact that as many as five ascents per day were made on about thirty days, to a height of 10,000 feet, as a result of which considerable insight into variations of temperature in

the upper air during the course of a day is provided. It appears that above a height of about 3 000 feet there is normally very little diurnal change of temperature though at the surface the temperature may not uncommonly range through as much as  $30^{\circ}\text{F}$  in the course of 12 hours.

The *Memoir* though mainly concerned with temperature conditions, also includes references to allied aspects of the aerology of lower Egypt as for example the diurnal variation of winds in the free air, haziness and bumpiness. It should be of interest to all aviators and meteorologists who are concerned with this region.

**GEOPHYSICAL MEMOIRS No 57** *Observations of smoke particles and condensation nuclei at Kew Observatory* By H. L. Wight M. A.

Since the beginning of 1928 observations have been made at Kew Observatory of the number of smoke particles and the number of condensation nuclei which are present in the air. In this publication the observations for three years are discussed with special reference to their variations with changes in the meteorological elements. In the winter months the average number of smoke particles in a cubic centimetre of air is 1 367 while in summer the average is only 180. In the case of condensation nuclei the contrast is less marked there being 38 000 per cubic centimetre in winter and 20 000 in summer. Easterly winds from London bring smoke particles to Kew Observatory in great numbers and light winds from any direction lead to excessive concentrations. While easterly winds are also associated with large numbers of nuclei the distinction with wind direction is not so marked as in the case of smoke particles. Smoke particles are produced by the combustion of coal in industrial furnaces and by the domestic fire the latter apparently being the most fruitful source while nuclei originate in the combustion of coal and of gas.

## Discussions at the Meteorological Office

The subjects for discussion for the next two meetings are —

February 27th, 1933 — (a) *The relationship of climatic and geological factors to the position of soil clay and the distribution of soil types* By E. M. Crowther (London Proc. R. Soc. B 107 1930 pp. 1-30). (b) *Analyses of agricultural yield Part IV Water table movements on a farm in Egypt* By W. L. Balls (London Phil. Trans. R. Soc. B 221 1932 pp. 335-76). Open r—Dr B. A. Keen \*

\*The discussion of these papers has been postponed from January 18th owing to the illness of Dr. Keen.

## Royal Meteorological Society

The Annual General Meeting of this Society was held on Wednesday, January 18th, in the Society's House, 49, Cromwell Road, S. Kensington, Mr. R. G. K. Lempfert, C.B.E., M.A., Vice-President, in the Chair.

The Report of the Council for 1932 was read and adopted, and the Council for 1933 duly elected, Prof. S. Chapman, F.R.S., being re-elected President.

The Buchan Prize, which is awarded biennially for the most important original papers contributed to the Society during the previous five years, was presented to Mr. D. Brunt, M.A.

In the absence of the President through illness, his Address was postponed and the following papers were read:—

*E. G. Bilham, B.Sc.—Variations in the climate of York during the 60 years, 1871 to 1930, and comparison with Oxford.*

The paper is mainly devoted to a comparison of the climatological data for York (The Yorkshire Museum) during the two periods of 30 years, 1871-1900 and 1901-1930. It has commonly been asserted that since the turn of the century winters have become less "wintry" and summers wetter and less sunny. The data show that in the latter period mean temperature has risen in most months, the increase amounting to from  $1^{\circ}$  to  $1.5^{\circ}\text{F.}$  in January, March, May, October and December. Sunshine increased by approximately 30 per cent in November and decreased by approximately 15 per cent in February, March and May. Rainfall was on the average 7 per cent less in the latter period, the months showing the biggest changes being January (plus 12 per cent), February (minus 15 per cent), June (minus 15 per cent), July (minus 12 per cent), September (minus 28 per cent), October (minus 17 per cent) and December (plus 14 per cent). The results support the popular belief that winters have become milder, but there is no support for the supposition that summers have, on the whole, deteriorated since 1900. The season showing the most marked change is autumn, with 17 per cent less rainfall and 9 per cent more sunshine.

A similar investigation shows that at Oxford (Radcliffe Observatory) corresponding changes of temperature have occurred. Oxford has, however, experienced an increase of rainfall amounting to 22 per cent in spring and 14 per cent in winter, though winter sunshine has increased by 12 per cent.

Analysis of the data in 5-year and 10-year periods shows that the changes of sunshine and rainfall are not progressive, but arise merely from the "casual" variations of those elements. In the case of temperature there is some evidence of systematic change, which may or may not be due to a long-period cycle.

*J. E. Clark, B.Sc.—The York rainfall, 1831-1930; also 1811-24; and for the 114 years.*

The paper deals with the variations in the decadal means of

monthly and annual rainfall and in the number of rain days as recorded at York. While some of the changes brought out in this paper are also apparent from the tables and diagrams included in Mr. Bilham's paper, the present paper considers a much longer rainfall record than the previous paper.

*L. H. G. Dines M.A.—Mean values of the relative humidity at different heights in the atmosphere over England*

Tables are given of mean values of the relative humidity in the troposphere over England up to a height of 8 kilometres. The figures have been derived from observations made with hair hygrometers and their limitations are stated. An examination of records obtained within the stratosphere leads to the conclusion that the relative humidity in that region varies considerably as between different days, and that its mean value is of the order of 70 per cent with respect to ice.

## Correspondence

To the Editor *The Meteorological Magazine*

### The Colour of Moonlight

Mr. Bilham's physiological explanation of the apparent blue colour of the night sky as a contrast with the yellow colour of artificial light in the *Meteorological Magazine* for December no doubt accounts for part of the phenomena, but it does not seem to me to be complete. I think selective scattering must also play some part as in the blue of the day sky.

The streets of London contain a large number of powerful artificial lights. On my nightly journey through London I have at a few points such as Balham an elevated view across the housetops, but I cannot actually see any powerful lights. On hazy nights the air above these points appears to have a bluish tinge which I think is partly real and which can be accounted for on physical grounds.

Artificial lights in a street of tall houses have some resemblance to lights in a reflector: the main course of the light is upwards. The light shining upward into the haze is partly reflected, partly scattered and partly allowed to pass. Except in the case of a fog or dense low cloud, however, the particles are small, and the amount of light directly reflected is comparatively small. On the other hand the proportion of scattering is large, but the important point is that the scattering is greater in the shorter wave-lengths—that is, the blue end of the spectrum—than in the longer wave-lengths—the red end of the spectrum. Hence the haze, looked at horizontally, appears bluish, but the blue of the haze is not the pure blue of the sky, because the haze-particles are larger than the air molecules to which the sky blue is attributed, and so the scattering of the different wave-lengths is less unequal than in clear sky.



The night sky of London in fact reproduces in crude form a beautiful experiment by Tyndall, in which a beam of electric light was passed the length of a tube containing a cloud of fine particles. Viewed from the side, the tube shone with a blue light, which was purer the smaller the particles.

If it were not for this selective scattering, the hazy night air would obviously appear of the same colour as the artificial illumination, *i.e.*, yellowish. This may explain why a dense London night fog, which reflects or scatters the whole of the artificial light, appears yellow. I do not think the fog particles themselves have a noticeable yellow tinge.

C. E. P. BROOKS.

January 30th, 1933.

In reply to Mr. Bilham, I wish to state that I observed the blue sky on Hampstead Heath about 9.30 p.m. on October 17th, an hour which at that period of the year should be too late for any effects of lingering daylight. Moreover, the entire night was very bright and windy, and I have little doubt that the blue tint persisted right through the night. In contrast, the sky on the following evening, as observed in the same locality at the same time, was normal, the weather being just as fine and the moon having risen only 25 minutes later.

In the letter to *The Times*, as quoted by Dr. Simpson, I implied, or meant to imply, in saying that the night sky is ordinarily without colour, that it is without conspicuous colour. As a matter of fact, the normal moonlit sky appears to be a very dark blue rather than black. I recently questioned a boy scout who happened to be walking with me late one evening what he considered the colour of the moonlit sky to be, and he replied "Oh! a kind of bluey black."

Cases of conspicuous blueness like that of October 17th occur at infrequent intervals and are obviously connected with meteorological conditions. I have not studied the optics of the question sufficiently to be able to advance any explanation, but it does not appear to me very remarkable that the night sky should vary in hue and brightness. After all the daylight blue sky is never two days alike in quality or intensity! It is greatly to be desired that persons who live deep in the country away from the disturbance of artificial lights should make observations on the colour of the night sky.

L. C. W. BONAGINA.

35, Parliament Hill, Hampstead, N. W. 3. December 31st, 1932.

### A "Perfect" Lunar Halo

On the evening of February 1st, when leaving the house soon after seven, my attention was at once attracted by a striking lunar halo. The moon, nearing the half stage, stood out sharply, although rather dim, from a circle of uniform and marked

darkness ringed in by a brilliant white halo, under  $2^{\circ}$  in width. The inner edge was exceedingly sharp, but after  $\frac{1}{2}^{\circ}$  it shaded off gradually, ending to the east by Aldebaran.

The whole sky seemed hazy and yet the film must have been thin and presumably very homogeneous. For Vega, although so low just west of north shone little less dimly than Aldebaran. Light fleecy clouds obscured the stars here and there. There had been little change by 7.30, but on coming away at 8.45 the film had gone and stars were bright in rifts between stretches of fleecy clouds. These moved only slowly, suggesting high altitude.

J. EDMUND CLARK.

Street, Somerset. February 3rd, 1933.

### Conical Hailstones

During a shower of soft hail which occurred in the evening of January 17th between 21h. 45m. and 22h., I observed the hail to be of a peculiar conical shape with round base, which I consider to be rather unusual. Many of the smaller granules were round in shape as commonly observed. The conical ones were fully a quarter of an inch in length and breadth and were opaque, white and relatively soft on the outside, becoming more solid inside. On the morning of the 18th the soft hail was still lying, but had become quite solid. The air temperature (in Stevenson screen) at the time of the shower was 33 degrees. The surface wind was easterly, 2 m.p.h., while the cloud from which the hail fell was moving from the WSW. In addition to the above, other unusual features for this time of year were the mountainous banks of cumulus and cumulo-nimbus clouds which occurred during the morning; some well-developed "anvils" of "false cirrus" were also observed, while thunder and lightning occurred to the south-west at 10h. and again at 19h. 09m. to the south-east. At 19h. 09m. the lightning was very vivid. Hail of the ordinary transparent form (small in size), sleet, and snow also occurred during the day, with frost morning and evening, that in the morning being sharp on the grass. The wind was light, and variable in direction all day and frequently falling calm.

A. E. MOON,

39, Clive Avenue, Clive Vale, Hastings. January 10th, 1933.

### NOTES AND QUERIES

#### The Colour of Moonlight

Referring to the correspondence on this subject in the *Meteorological Magazine*, Prof. A. Schmauss, Director of the Bayer. Landeswetterwarto, Munich, has called attention to a recent paper by W. M. Cohn,\* who suggests that the blue of the sky

\*Elektronenbombardement als Faktor bei atmosphärischen Erscheinungen. *Beitr. Geophysik. Leipzig*, 37, 1932, pp. 108-223.

may be partly due to the bombardment of the upper atmosphere by cathode rays from the sun. The fluorescent blue light produced by cathode rays in nearly exhausted tubes is well known, and Cohn argues that the same phenomenon occurs in the highest air at pressures of about one ten-thousandth of a millimetre. He considers that this light is excited by electrons emitted from the sun, which strike all parts of the atmosphere, some of them following curved paths which bring them into the night hemisphere, though the majority fall on the side of the earth turned towards the sun. He even regards the fluorescence excited by these rays as forming an appreciable part of the blue of the day sky, on the grounds (1) that the spectrum of the fluorescence is identical with that of the sky; (2) that the maximum polarisation of the sky light is only about 70 per cent, while Rayleigh's well-known theory of scattering by air molecules requires complete polarisation at a point 90 degrees from the sun; and (3) that polarisation decreases with increasing altitude, indicating that at high levels the proportion of unpolarised fluorescent light increases.

Cohn also states that the colour of the night sky, especially within the tropics, may be a deep blue; he does not state whether this remark applies when the moon is not shining, but he definitely attributes a large part of this illumination to fluorescence excited by electrons emitted from the sun and reaching the earth along curved paths.

The theory of electronic bombardment put forward by W. M. Cohn is open to a number of objections. Here it is sufficient to remark that the measured light of the moonless night sky, though about three times as strong as can be accounted for by the diffusion of starlight, is far below the threshold of colour vision, and is not blue but yellowish. Lord Rayleigh\* describes it as nearly the colour of a piece of paper illuminated by a half-watt lamp at normal incandescence, while J. Dufay† found it to have a spectrum similar to that of sunlight with the addition of the green "auroral" line.

### **The Journey of a Toy Balloon: Evidence for very strong upper Winds**

The following is an abstract of letters received from Mr. J. Bevan, Secretary of Pim Bros., Dublin:—

"On Monday afternoon, November 14th, about 400 balloons were released from the roof of the building of Messrs. Pim Bros., Dublin, in connection with an advertisement of the opening of the Christmas show in the toy department. When blown up the balloons were about 18in. by about 12in.-14in.

\*Some recent work on the light of the night sky. *Nature*, 122, 1928, p. 815.

†Spectre, couleur et polarisation de la lumière du ciel nocturne. *J. Phys. Radium*, (6), 10, 1929, pp. 219-40.

diameter, and were filled with hydrogen. On being released they were borne away in a south-westerly direction and continued to rise until out of sight. Up to December 7th a'even had been returned: two from Dublin, two from County Limerick, two from France and five from England; a few more were found later.

One in particular was stated to have been found that night at 7.30 p.m. near Ashford, Kent, and was posted to us on the Tuesday, being delivered here on Wednesday morning. This appears to us to be almost phenomenal—that a balloon should travel first in a south-westerly direction and be found four hours later at a point some 300 miles south-east of its starting point. Is there any record of a similar occurrence?

On the next day at about 11 a.m. another balloon was found near Ashford; one was found near Caen, Normandy, at 9.30 a.m., another on the sea 10 Km. north of Dioppe by a fawler captain. Other balloons were found as follows:—

Bunwell, Norwich, 11 a.m. Tuesday, November 15th;

Southminster Marshes, Essex, 10.30 a.m. Tuesday, 15th;

Felsham, Bury St. Edmunds, Saturday, 26th.

The various directions are no doubt accounted for by varying directions of winds at various heights—the day was very dull, there being heavy clouds, but it was not raining."

Mr. J. Strover, of Forge Row, Westwell, near Ashford, has been so good as to confirm the report that it was at 7 or 7.30 on Monday night that he found the balloon mentioned in Mr. Bevan's letter. Mr. Strover says that the balloon was still filled with gas. Moreover, Mr. Bevan assures me that there was no possibility of any of the balloons being released earlier than the Monday afternoon, as the hydrogen cylinder was not obtained until the Monday morning.

On November 14th the gentle current from NE. in the lower atmosphere was general over Ireland. There is practically no meteorological evidence with regard to movements at higher levels. It is remarkable that just the one balloon should have ascended so far as to get into the powerful NW. wind which, it would appear, must have been blowing at about 100 m.p.h.

F. J. W. WHIPPLE.

### **Meteorological Conditions during the World's Altitude Record Flight for heavier-than-air Aircraft**

On September 16th, 1932, the record height of 43,976 feet was attained by a Vickers' "Vespa" aeroplane fitted with a Bristol "Pegasus" S.III engine, and piloted by Flight-Lieut. C. F. Uwins, Chief Test Pilot of the Bristol Aeroplane Company. The aeroplane had been specially adjusted for the flight and several preliminary tests were made before the actual record was established.

During the test climbs and on the record flight the stratosphere was penetrated and the notes made by the pilot regarding weather conditions and the temperatures recorded offer several points of interest. Air temperatures were obtained from a strut thermometer (nitrogen filled) reading to  $-65^{\circ}\text{C}$ . The following notes and table of observations are extracted from the report supplied by the Bristol Aeroplane Company:—

"The weather during all the flights was fairly clear, but on the last flight the sky was covered by broken cloud at 2,000 feet. The following observations were made:—

*Temperature.*—Air temperature generally fell until a minimum was reached in the neighbourhood of 35,000 feet. On the actual record climb the temperature at this height was  $-50^{\circ}\text{C}$ ., while the temperature at 44,000 feet was  $-56^{\circ}\text{C}$ . The temperature between these heights was steady at  $-55^{\circ}\text{C}$ .

On one climb a temperature of  $-58^{\circ}\text{C}$ . was recorded at 38,000 feet, while the lowest temperature recorded in all the climbs was  $-63^{\circ}\text{C}$ .

It is of interest to observe that a slight reversal of temperature was recorded on three occasions at a height of 40,000-42,000 feet.

On the test climb made on September 7th, 1932, the minimum temperature recorded was  $-52^{\circ}\text{C}$ . at 35,000 feet, above which a steady rise in temperature occurred until at 41,500 feet it stood at  $-46^{\circ}\text{C}$ . This reversal was verified during the descent.

*Clouds.*—Clouds were experienced up to 35,000 feet.

*Bumps.*—Bumps were experienced at various heights. The most noticeable were on the final test when fairly rough air was encountered at 44,000 feet.

*General.*—Conditions at height were generally good. Visibility was excellent, and the only discomfort was experienced when climbing towards the sun. This was extremely bright and made all instruments very difficult to read.

Coloured glasses or some form of eye-shade should prove helpful when flying at these heights."

Height Feet	Time		Air Temperature $^{\circ}\text{C}$ .
	Min.	Sec.	
O.G.	—	—	18
10,000	9	00	9
15,000	—	—	—
20,000	24	45	-14
25,000	35	00	-26
30,000	45	00	-38
35,000	57	00	-50
40,000	72	00	-55
43,500	96	00	-55
49,500	103	00	-56

The flight was made when a belt of high pressure extended

across the British Isles connecting anticyclones centred over southern Germany and the eastern Atlantic. The wind circulation over the British Isles was associated essentially with the former of these two anticyclones, the surface wind in southern England being mainly light, easterly and veering with height to between S. and SE. at 10,000 feet with little change of speed. In the upper air the temperatures at all levels were above the September normal, the excess decreasing from  $9^{\circ}\text{C}.$  at 10,000 feet to  $5^{\circ}\text{C}.$  at 20,000 feet and to  $2^{\circ}\text{C}.$  at 30,000 feet. Observations made at Duxford on September 16th and the two preceding days indicated that the air was slowly descending, as shown by the rise of temperature and decrease of relative humidity in the middle levels.

The report of clouds up to 35,000 feet is of interest, in that synoptic reporting stations near to Bristol make no reference to cirrus clouds on this day. This may be accidental owing to the cloud not being observed at the time of observation or because of the cloud being too thin to be observed through the haze layer.

The bumpiness at 44,000 feet is rather remarkable in view of the notes regarding the constancy of air temperature between 35,000 feet and the maximum height reached. On another occasion a local, very bumpy patch was encountered at about 43,000 feet. This patch was above a big cloud of the cumulonimbus type. After passing through this patch, the air was again quite steady. This may form a small piece of evidence in support of the view that convection and cloud formation are possible in the stratosphere.

R. S. R.

### Recent Meteorological Work in India

The arrival of a batch of thirteen numbers in the *Scientific Notes* of the India Meteorological Department provides striking evidence of the activity of the staff, an activity that has in the last four years produced 47 of these Notes and 7 of the larger series of Memoirs, as well as several papers in the *Philosophical Transactions of the Royal Society* and in the *Beiträge zur Physik der freien Atmosphäre*.

The Indian department was started in 1875, so that the number of those who remember H. F. Blandford, its able founder, is extremely small. But of the tireless energy and heroic devotion to duty of his successor Eliot the reviewer has vivid recollections. Eliot worked twelve hours or more every day of the week, and spent the greater part of his last years of office in organising and checking the calculation of normals, himself correcting the proofs, in order that when he handed over his duties, the knowledge of the history of the 180 observatories, which he alone possessed, should be utilised to the full. He would sometimes speak with longing of the future years when

the Director would have a trained scientific staff and facilities for research; and material extension along these lines was obtained by him shortly before his retirement.

The first of the present group of papers (Vol. III, No. 18), by K. R. Ramanathan and A. A. Narayana Iyer, is a study of a tropical storm and finds in it a warm front in some respects similar to that found in European depressions. But the fall of pressure was slight and the sea data scanty. In the second (III, 19), by V. N. Ghosh, are given the monthly distributions of air density at M.S.L. over India; and in the third (III, 27), by B. N. Desai, we have a classification of the conditions that produced thunderstorms at Poona in 1930.

It is particularly pleasing to the reviewer to see two papers (III, 29, and IV, 38), by V. Doraiswamy Iyer, who in his earlier years of routine work in the department had little chance of research. His first paper is a study of the very destructive Bengal cyclone of September, 1919, and in the second it is shown that the monsoon rainfall of Siam, excluding a portion of the Malay peninsula, varies in close relationship with the monsoon rainfall of north-west India and can be forecast with a correlation coefficient of 0.81. The parallelism with north-west India is curious, for Burma has a marked negative relationship with the southern oscillation and China is independent of it.

In addition to the joint paper (III, 18) already noticed, K. R. Ramanathan contributes a paper (III, 30) on the structure of the sea breeze which sets in at Poona on many evenings between February and May; he uses special observations with pilot balloons. He also has a second joint paper (IV, 34) with H. C. Banerjee, in which pre-monsoon storms in the Bay of Bengal are compared with winter storms in the Bay; in the former warm dry land air ascends over cooler, damper sea air, while in the latter the moister air is the warmer. These investigations into storms are much needed in view of the present difficulty in foreseeing at certain times whether a storm will move north-west or north-east. In Note IV, 31, S. K. Pramanik, in collaboration with S. C. Chatterjee and P. P. Joshi, continues his examination of lunar atmospheric tides, showing that at Kodalkanal at 7,688 feet above sea level the mean amplitude is the same as at Periyakulam, at 944 feet.

The next paper (IV, 32), by S. Atmanathan, deals statistically with the inferences for daily weather forecasting that can be derived from the temperature difference between Simla at 2,204 m. and Ambala on the plains 135 Km. distant at 272 m. above M.S.L. This difference had long been used, and Ramanathan had studied the sounding-balloon ascents at Agra for the effects of variations in the vertical temperature gradient; but the data of hill stations afford only a rough indication of the

temperature in the free air, and it was desirable to ascertain how far the ordinary daily observations at Simla and Ambala could be relied upon in forecasting. The verdict is definite and satisfactory.

V. V. Sohoni provides in IV, 33, an interesting application of Normand's wet-bulb theory to show that the Calcutta thunderstorms, usually nor'westers, are not due merely to heat, for the wet bulb falls very nearly as much as the dry, and in 95 per cent of the storms there is a decrease of absolute humidity; they are due to the over-running of warm, moist air from the Bay by cold, dry air from north India. The next paper, IV, 35, is by G. Chatterjee, who was trained by Field to take charge of upper-air work at Agra. It gives an improved method of sounding with an ingenious self-deflating balloon that is turned upside down at 3 Km. and empties the hydrogen from its open mouth; the meteorograph has a double temperature-grid with a more open scale than the Dines instrument. In association with P. M. Neogi, Chatterjee describes in IV, 36, two ingenious contrivances for lifting the pens off the recording plate of the meteorograph before it reaches the ground so as to avoid the blurring of the lower portion of the trace.

The last paper (IV, 37), by S. R. Savur, examines the reviewer's method of seasonal forecasting. His original formula of 1908 was for India as a whole, and in 1924 he developed a more ambitious scheme of foreshadowing the winter precipitation of north-west India and the rainfall of the Peninsula and of north-west India, both for June to September and for August and September. For the monsoon rainfall of north-east India little success was claimed, and inasmuch as subsequent theory has shown that a forecast with a 4:1 chance of success could only have been made for this region once in six years, its formula may be definitely set aside. The inclusion of between six and ten more years and the use of a statistical expression worked out by Fisher in 1928 has enabled Savur to apply an effective criticism. In his verdict he says:—"It is not a little surprising that only seven out of 28 factors have been found by this stringent test likely to become insignificant in the long run"; and it may be noted that for the monsoon forecasts of the Peninsula and north-west India the corresponding statement would be three out of 32.

The general impression left by these *Scientific Notes* is one of satisfaction due to their objective character. In the early days both of some departments and some individuals, there is a tendency towards an overdue use of intuition and a consequent lack of fibre; an over-hasty rushing into print is not unknown. But here a series of problems covering a wide range have been studied and the department is to be congratulated on the definiteness of the results that have been reached.

G. T. WALKER.



### The lowest recorded Barometric Pressures at mean sea level

On January 3rd, 1933, during the passage of a deep depression from south to north across Iceland, the pressure at Reykjavik at 7h. fell to 927.2 mb., and earlier in the morning the reading was probably still lower. This is among the lowest barometer readings recorded at sea level in temperate regions. Other records are:—

925.5 mb. at Ochtertyre, Perthshire, January 26th, 1884.

925.5 mb. on H.M.S. *Tarifa* in the Atlantic, 51°3'N., 23°59'W. on February 5th, 1870.

927.2 mb. at Belfast on December 8th, 1886.

927.9 mb. on s.s. *Westpool* in the Atlantic, on December 4th, 1929.

Much lower pressures have been recorded from time to time in tropical cyclones. By far the lowest known is a reading of 886.8 mb. (26.185 in.) on August 18th, 1927, on the Dutch steamship *Saparaca* in the Pacific, 460 miles east of Luzon (Philippines). This phenomenal reading was quoted in *Nature* for August 18th, 1928, p. 281. A barograph was on board, but the pen passed off the chart, and readings were made with a mercurial barometer; the lowest reading was checked by several persons. Other low readings are 915.7 mb. on board a ship near Grand Turk Island on September 27th, 1880, and 918.9 mb. at False Point Lighthouse, Orissa, Bengal, on September 22nd, 1885.

It is possible that still lower pressures exist in the funnel clouds of tornadoes, though no actual records exist. As is well known, when a tornado passes over a building, the difference between the pressure of the air inside the rooms and that outside sometimes causes the walls to be burst outward or the roof to be lifted off, but the forces which would be set up by a sudden drop of pressure by even 100 mb. would probably be more than sufficient to account for all the observed damage of this nature.

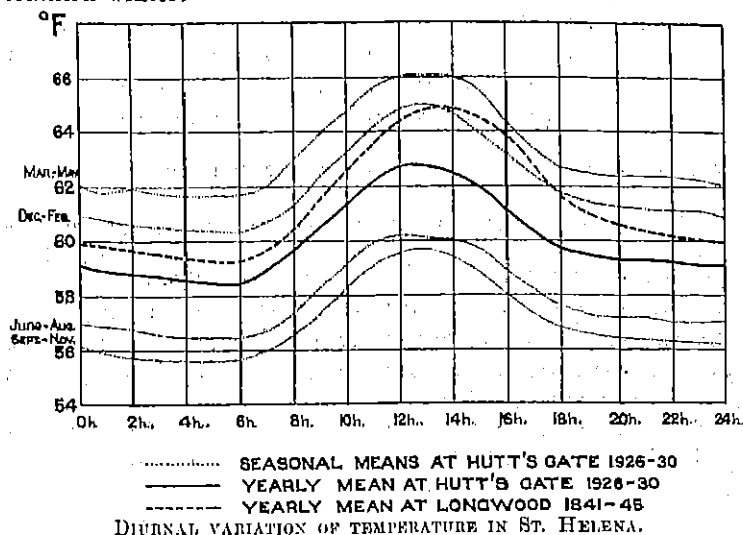
### The diurnal Variation of Temperature in St. Helena

The island of St. Helena occupies a position in the South Atlantic Ocean which from a meteorological point of view is of great importance and interest. Its length is only about eleven miles and its width approximately seven miles, so that the climate is almost purely oceanic, and it lies in the path of the south-east trade winds.

The station is at Hutt's Gate, near St. Matthew's vicarage, in the centre of the island, at a height of about 1,900 feet above M.S.L. In 1926 a bimetallic thermograph was installed and was working intermittently until September, 1930. Despite many breaks in the records there are sufficient observations in that period to warrant an attempt to exhibit the diurnal varia-

tion of temperature at this station.

The values from which the curves in the accompanying diagram are constructed were read from the autographic curves and corrected by eye observations taken at 6h. 30m. It will be seen that the maximum temperatures occur at the end of the southern summer and the minima at the conclusion of the southern winter.



Another noticeable feature of the diagram is the flatness of the curves around the time of the minima, which is characteristic of an oceanic position. There is no definite rainy season at St. Helena, but it may be noted, for purposes of comparison, that the rainfall is greatest in autumn (March to May) and least in spring (September to November). The curves are drawn for G.M.T., local time being 22 minutes behind this.

An interesting comparison may be made with the results of a series of eye observations taken by a detachment of the Royal Artillery in the years 1840-5 at Longwood, which is situated on an elevated plain about a mile distant from St. Matthew's vicarage and 135 feet lower. From September, 1840, to August, 1842, the observations were two-hourly, and from September, 1842, to December, 1845, they were hourly. It will be seen that the mean curve for these early observations is from about 1°F. to 3°F. higher than that for 1926-30. This may be accounted for partly by the difference in position and height, and partly by the fact that at Longwood "the thermometers were fixed to horizontal battens, the bulbs being quite free. They were placed in front of a window (through which they were read)

under a deep verandah on the south side of the observatory, and were screened by the form of the building from all but a south-eastern aspect."\*

TABLE I. HOURLY MEANS OF TEMPERATURE IN ST. HELENA (HUTT'S GATE), 1920-30.

	1	2	3	4	5	6	7	8	9	10	11	12
Sept.-Nov.	55.9	55.8	55.7	55.7	55.0	55.7	56.0	56.0	57.4	58.4	59.1	59.0
Dec.-Feb.	60.8	60.6	60.6	60.5	60.4	60.3	60.7	61.8	62.4	63.2	64.2	64.8
Mar.-May	61.8	61.9	61.8	61.7	61.7	61.7	62.0	63.0	63.9	64.7	65.0	66.0
June-Aug.	56.9	56.8	56.6	56.5	56.5	56.5	56.7	57.4	58.3	59.2	60.0	60.2
Year -	58.0	58.8	58.7	58.0	58.5	58.5	58.9	59.0	60.5	61.4	62.2	62.7

	13	14	15	16	17	18	19	20	21	22	23	24	Day
Sept.-Nov.	59.7	59.4	58.8	58.0	57.3	56.8	56.0	56.5	56.4	56.8	56.2	56.2	57.1
Dec.-Feb.	65.0	64.7	63.9	63.2	62.4	61.8	61.4	61.8	61.2	61.1	61.1	60.0	62.0
Mar.-May	60.1	60.0	59.5	64.4	63.4	62.7	62.5	62.4	62.4	62.3	62.3	62.1	63.2
June-Aug.	60.1	60.0	59.7	58.9	58.2	57.6	57.8	57.2	57.2	57.0	57.0	57.0	57.9
Year -	62.7	62.5	62.0	61.1	60.3	59.7	59.5	59.8	59.3	59.2	59.1	59.1	60.1

The hourly means for Hutt's Gate for the four seasons and the year are given in Table I.

L. H. POWERS.

### Black Snow at Eskdalemuir in 1897

Mr. Richard Bell, of Castle O'er, in his "My strange Pets and Other Memories of Country Life" (Blackwood, 1905), describes a fall of black snow in the parish of Eskdalemuir, and an account of it may prove of interest.

Mr. Bell tells us that a fall of black snow took place on the evening of January 30th, 1897. On the following morning, whilst taking a walk in his avenue, he noticed that the marks made by his footsteps "were pure white below the coloured surface of the snow, which was of quite a dark colour in comparison." On investigating the peculiarity, he found that the surface of the unbroken snow to the depth of about a quarter of an inch was deeply coloured as if mixed with soot. The author goes on to say—and I cannot do better than to quote the actual words of this careful observer—"Having gone further afield during the day I found the whole of the snow on the road and hillsides was of the same black colour; and on looking across the valley the hills

\*Climatological Tables for St. Helena. By J. S. Dines, London, Meteor. Office (M.O. 208), 1910.

appeared as if they were bathed in the lights and shadows, as seen during bright sunshine. As the day was dull, sunshine could not account for this peculiar appearance; and it was evident that it was caused by the wind during the time the snow fell. The wind swept the more salient parts of the hill and deposited the fall of coloured snow in the hollows, thus giving the country the appearance of light and shadow. The area over which the snow fell was, to my own knowledge, four miles long by about a mile and a half wide."

It appears that soot from the chimneys of some manufacturing town must have been responsible for the discoloration of the snow, but as the prevailing winds were of a light order, it is impossible to say whether an English or Scottish town caused the phenomenon.

G. B. KINGSTON JAMES.

## Reviews

*Periodicity in solar variation.* By C. G. Abbot and Gladys T. Bond. *Smiths. Misc. Coll.* Vol. 87, No. 9, pp. 1-14, *Illus.* 1932.

In this paper Dr. Abbot continues his studies of the relations between solar variations and terrestrial weather. Analysing the variations of the solar constant from 1920 to 1931 he finds periodicities of 7, 8, 11, 21, 25, 45 and 68 months, all of which are fractions either of the sunspot cycle of 135 months or the Brückner cycle of three times this length. Analysis of temperature variations at three places in the United States shows these periodicities, as well as several others which are presumed to be of terrestrial origin, but the total amplitude of the solar periods is about twice that of the terrestrial, showing that the control of weather is mainly solar. These results are employed to calculate the temperatures for the years 1916 to 1918, but for various reasons the agreement between observed and calculated figures is not very good and the method requires to be improved.

*Regenal in Nederlandsch-Indië.* By Dr. J. Boerema. *Kon. Magn. Meteor. Obs., Batavia.* Vorh. No. 24. Part I. Vol. 1, size 11 x 7 in., pp. viii + 244, and Vol. 2, size 24 x 20 in., pp. 15.

In this series the meteorology of the Netherlands Indies is considered separately for two main areas (a) Java and Madoera, and (b) the remainder of the Archipelago, including Sumatra, Borneo and Celebes, and referred to as the "Buitengewesten." Vol. 1 is statistical and gives tables showing for each station (a) the mean annual and monthly rainfall in mm., (b) the mean annual and monthly number of rain-days, (c) the mean maximum daily

rainfall in mm. for each month and for the year, and (d) the absolute daily maximum. For stations in the Buitengewesten, which are shown in a separate table, the period of observation is given as well as the number of years for which records are available, and the altitude of the station. The results of the rainfall observations made at 2,715 stations during the period 1879 to 1922, were published in 1925 in Verh. No. 14, which was accompanied by an atlas containing maps of the annual and monthly rainfall in Java and Madoera. Verh. No. 24, Vol. 1, contains statistics for 3,293 stations with at least five years' record during the period 1879 to 1928. Alphabetical lists of the stations are given separately for the two main areas, together with numbers, which can be used to identify the stations in the other tables and on the maps. Vol. 2 gives maps of the mean annual and monthly rainfall in Sumatra, together with a map showing the positions of the rainfall stations. All the maps are on a scale of 1:3,000,000 (48 miles to 1 in.). An atlas of Borneo and Celebes is being prepared.

The maps show that the average annual rainfall exceeds 1,000 mm. (39·4 in.) over practically the whole of Sumatra. About this amount occurs in the extreme north and over small inland regions in the northern half. More than 7,000 mm. (276 in.) occurs locally in a mountainous region, about the middle of the south-west coast near Padang. The range is shown by the monthly averages set out below, as taken from Vol. 1 (but converted to inches) for the two stations at Kroeŋgraja and Indaroeng:—

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
8·2	3·3	4·5	4·3	2·6	0·9	1·1	0·8	3·1	3·0	5·1	8·4	43·3
20·0	15·1	21·3	21·6	18·6	14·2	13·7	17·3	22·3	20·2	20·2	24·3	243·8

The variations of the annual totals from place to place and their distribution throughout the year depend on a large number of factors. These factors are discussed in some detail in Verh. No. 18.

Some of the largest numbers of rain-days occur in Java, where thunderstorm rains occur most afternoons, especially at the change from one monsoon to the other. The largest mean number of rain-days is 284 for Goenoeng Pangrango, in Java, but this station is also at an altitude of 3,023 metres.

Practically every one of the 3,293 stations in Vol. 1 has recorded 4 inches in a day, while most stations received that amount at least once every year. The largest amounts reported for the rainfall day are 23·6 in. at Tjondana in Semarang (Java), and 24·6 in. at Tahorre (Molukken). These heavy rains, caused by the passage of monsoon winds over mountainous regions near the coasts, are generally prolonged and often give large monthly totals.

J. GLASSPOOLE.

## News in Brief

Mr. E. J. L. Joss, the meteorological observer at the Grichton Royal Institution, Dumfries, retired on pension on January 31st, 1933. Mr. Joss has for over 21 years forwarded regularly climatological returns for both the *Weekly Weather Report* and the *Monthly Weather Report*. His monthly climatological returns were consistently of a high standard, being amongst the best received in Scotland.

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## Erratum

*Meteorological Magazine* for January, 1933, p. 285, line 13, and also in the Index, p. vi, for "L. A. Harwood" read "W. A. Harwood."

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## The Weather of January, 1933

Pressure was above normal over western Asia, the whole of Europe except the extreme south-west, central North Atlantic, Newfoundland, and the south-western United States, the greatest excess being 19.1mb. at Vaigatsch, Arctic Russia; the excess in eastern Sweden was 8 to 9mb. Pressure was below normal over Alaska, Canada, central, northern and eastern United States, Greenland, Iceland and Spitsbergen, southern North Atlantic, the Iberian Peninsula, south Italy and northern Africa, the greatest deficit being 16.3mb. at Isafjord. Temperature was above normal over northern Europe, 23.7°F. above normal being recorded at Spitsbergen and 7°-9°F. above in Norrland. Rain-fall was mainly above normal, with 26mm. excess at Zurich. Over the British Isles, however, and parts of Scandinavia precipitation was less than normal, Kew having a deficit of 11mm. and Vardo of 43mm.

During the first week of the month an exceptionally deep depression passing across Iceland caused stormy and mild weather over the British Isles; a gust of 71 m.p.h. was recorded at Holyhead on the 2nd. Rain occurred most days in all districts although the 6th was generally fine in the east; there were heavy falls on the 2nd, notably 3.10in. at Borrowdale, 2.55in. at Helne, S. Devon, and 2.57in. at Llyn Fawr Reservoir, Glamorgan. Thunderstorms occurred at Stornoway, Dumfries, Valencia and The Lizard on the 4th and at Ventnor on the 5th. Temperature was high during this week, especially on the 2nd when maxima of 55°F. and over were recorded; it fell, however, on the 7th when there were rather low minima. By the 9th the country came under the influence of an extension of the Azores anti-cyclone, and the weather was mild and sunny. It became colder in England and Scotland on the 10th and a minimum of 22°F. was recorded in the screen at Marlborough and Rhayader. During the next few days a series of troughs of low pressure

crossing the country caused rain and sleet in the north and occasional rain in the south; there were gales in the north, force 9 being reported at Lerwick on the 14th. From the 15th to the 17th there was snow in many parts of England and Scotland. On the 20th an anticyclone over Russia extended over the British Isles and a period of easterly winds set in with cold, dry weather. At many places maximum temperatures did not rise much above the freezing point, there was, however, a good deal of sunshine. This weather continued into the fourth week when some low maximum temperatures were recorded, notably, 29°F. at Bristol on the 24th and 28°F. at Renfrew on the 24th and 25th. A night minimum of 15°F. occurred at Durham and Rhayader on the 23rd and at Dumfries on the 25th. The Valentia night minimum of 23°F. on the 25th was the lowest in January since 1907. Outdoor skating became general for the first time since the cold spell of February-March, 1929, and lasted until the 29th. After the 25th the cold air from Russia was diverted and temperature gradually rose, although Renfrew reported a maximum of 26°F. on the 28th. There was a good deal of sunshine during this week—in the south on the 22nd (7·8 hrs. at Guernsey) and generally in England on the 26th, 27th and 28th, many places recording more than 7 hrs. on some of these days. Disturbances from the Bay of Biscay and the Atlantic brought unsettled weather after the 29th with gales on the 31st. Very heavy rain was recorded in the north of England and in Scotland during the night of the 31st, 2·60in. fell at Eskdalemuir, 2·54in. at Falstone Rectory, Northumberland, and, in the Lako District, 5·50in. at Borrowdale (Watendlath Farm) and 5·83in. at Haweswater (Burn Banks). The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	38	+10	Liverpool	67	+12
Aberdeen	53	+ 5	Ross-on-Wyo	91	+45
Dublin	84	+27	Falmouth	81	+26
Birr Castle	77	+28	Gorleston	72	+13
Valentia	66	+18	Kew	30	— 4

The special message from Brazil states that the rainfall was irregular in the north and centre with averages 55in. and 79in. above normal respectively, and scarce in the south with an average of 1·81in. below normal. The circulation was active; four anticyclones passed across the country and vigorous depressions accompanied by much wind. The crops were in good condition except the corn in the south. At Rio de Janeiro pressure was 0·1mb. above normal and temperature 1·1°F. below normal.

*Miscellaneous notes on weather abroad culled from various sources.*

A violent storm at the beginning of the month on the west coast of Norway caused damage to shipping estimated at £50,000. The first part of the month was unusually mild and dry in Switzerland with very little snow, especially in the Bernese Oberland. Snow, however, fell on the 16th in the low country as well as on the mountains. A snowstorm which swept eastern Switzerland on the 21st caused the lower passes to be blocked. From the 22nd for about 6 or 7 days intense cold prevailed generally over the Continent, on the 23rd the temperature at 1 p.m. was below freezing point from the south of France to Scandinavia and eastwards to Siberia, the temperature becoming progressively lower to the east. For two or three days a gale blew over the Alps, temperature fell below 0°F. in the mountains, Jungfrauoch recording -15°F. The frost was severe in Germany, ice breakers were required on the Oder and the Elbe, and on the 25th traffic on the Rhine was suspended, the ice block extending for 25 miles from Coblenz to Kaub. In Berlin the temperature fell almost to 0°F. and -13°F. was recorded in eastern Prussia. It was very cold in parts of Spain, -11°F. being recorded at Teruel; snow fell on the 25th at Valencia and Castellon for the first time this century. During the last few days of the month conditions were less severe and in many parts a thaw set in. In the latter part of the month the weather in northern Algeria was stormy and there was thick snow on the mountains. (*The Times*, January 4th-31st.)

During the first few days of the month heavy weather in the North Atlantic delayed liners making for New York, which were in some cases as much as three days late. Weather was generally mild and fair at the beginning of the month in the United States, towards the middle of the month cold waves of short duration crossed the country, but subsequently temperature became again generally above normal. From 17th-20th a depression of considerable energy moved north-eastwards from the extreme south-west, it was accompanied by widespread precipitation in the central and northern States. On the 26th-28th gales and flood tides caused extensive damage along the New England and Nova Scotian coasts, houses were washed out to sea and roads were destroyed. (*The Times*, January 4th, 30th and 31st, and *Washington, D.C., U.S. Dept. Agric. Weekly Weather and Crop Bulletin*.)

**General Rainfall for January, 1933**

England and Wales	...	93	} per cent of the average 1881-1915.
Scotland	...	103	
Ireland	...	90	
British Isles	...	<u>95</u>	



## Rainfall: January, 1933: England and Wales.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>London</i>	Camden Square .....	1.34	72	<i>Leics.</i>	Thornton Reservoir ...	1.86	93
<i>Kent</i>	Tontorden, Ashendon...	2.10	100	"	Belvoir Castle.....	1.81	102
"	Folkestone, Boro. San.	2.97	...	<i>Rut.</i>	Ridlington.....	1.23	66
"	St. Peter's, Hildersham	.56	32	<i>Linces</i>	Boston, Skirbock .....	1.48	91
"	Eden b'dg., Falconhurst	2.20	90	"	Cranwell Aerodrome ...	1.46	85
"	Savenoaks, Speldhurst	1.00	...	"	Skegness, Marine Gdns	1.20	69
<i>Sussex</i>	Compton, Compton Ho.	2.61	88	"	Louth, Westgate .....	1.61	74
"	Patching Farm .....	2.55	98	"	Brigg, Wrawby St. ....	1.65	...
"	Eastbourne, Wil. Sq.	2.34	89	<i>Notts</i>	Worksop, Hocknook ...	1.68	95
"	Heathfield, Barklye ...	2.70	100	<i>Derby</i>	Derby, L. M. & S. Rly.	1.56	78
<i>Hants.</i>	Ventnor, Roy. Nat. Hos.	2.60	101	"	Buxton, Torr. Slopes	2.85	94
"	Fordingbridge, Oaklands	2.54	92	<i>Ches.</i>	Runcorn, Weston Pt. ...	1.38	58
"	Ovington Rectory .....	3.00	113	<i>Lancs.</i>	Manchester, Whit Pk.	2.01	80
"	Shorborne St. John ...	2.45	105	"	Stonyhurst College ...	3.09	80
<i>Herts.</i>	Wolwyn Garden City...	1.78	...	"	Southport, Hesketh Pk	2.30	90
<i>Bucks.</i>	Slough, Upton .....	1.78	96	"	Lancaster, Greg Obsy.	3.57	102
"	H. Wycombe, Blackwell	2.00	...	<i>Yorks.</i>	Wath-upon-Deane ...	1.68	87
<i>Oxf.</i>	Oxford, Mag. College...	1.60	98	"	Wakefield, Clarence Pk.	1.88	98
<i>Nor.</i>	Pittsford, Sedgbrook...	1.45	78	"	Oughtershaw Hall.....	5.02	...
"	Oundle.....	1.00	...	"	Wetherby, Ribston H.	2.24	100
<i>Beds.</i>	Woburn, Crawley Mill	1.40	82	"	Hull, Pearson Park ...	1.12	62
<i>Cam.</i>	Cambridge, Bot. Gdns.	.98	65	"	Holme-on-Spalding ...	1.80	...
<i>Hamp.</i>	Chelmsford, County Lab.	1.20	78	"	West Witten, Ivy Ho.	3.31	104
"	Lexden Hill House ...	1.33	...	"	Felixkirk, Mt. St. John	1.08	90
<i>Suff.</i>	Haughley House.....	.78	...	"	York, Museum Gdns.	1.83	103
"	Campsea Aerie.....	.95	62	"	Pickering, Hungate ...	1.79	80
"	Lowestoft Sec. School	.89	53	"	Scarborough .....	1.32	60
"	Bury St. Ed., Westley H.	1.42	79	"	Middlesbrough .....	2.39	149
<i>Norfol.</i>	Wells, Holcham Hall	1.08	74	"	Baldordale, Hury Res.	2.71	83
<i>Wills.</i>	Davizes, Highclere.....	2.53	118	<i>Durk.</i>	Ushaw College .....	1.78	87
"	Calne, Castleway .....	2.20	96	<i>Nor.</i>	Newcastle, Town Moor	1.32	65
<i>Dor.</i>	Evershot, Malbury Ho.	5.07	140	"	Bellingham, Highgreen	2.39	84
"	Weymouth, Westham.	1.96	81	"	Lilburn Tower Gdns...	1.37	66
"	Shaftesbury, Abbey Ho.	2.41	93	<i>Chamb.</i>	Carlisle, Scaleby Hall	2.03	106
<i>Devon.</i>	Plymouth, The Hoe...	2.47	74	"	Borrowdale, Seathwaite	16.50	181
"	Holm, Church Pk. Cott.	6.93	112	"	Borrowdale, Moraine...	13.90	...
"	Telgumouth, Den Gdns.	2.44	84	"	Keswick, High Hill...	9.04	179
"	Cullompton.....	1.90	69	<i>West.</i>	Appleby, Castle Bank	4.28	132
"	Sidmouth, Sidmouth...	2.20	77	<i>Mon.</i>	Abergavenny, Larch...	3.56	105
"	Barnstaple, N. Dev. Ath.	2.60	80	<i>Glam.</i>	Ystalyfera, Wern Ho.	7.13	113
"	Dartm'r, Cranmere Pool	7.20	...	"	Cardiff, Ely P. Stn. ...	2.02	69
"	Okehampton, Uplands	5.02	98	"	Treherbert, Tynyvaun	0.91	...
<i>Corn.</i>	Redruth, Trowiegie ...	3.02	93	<i>Carm.</i>	Carmarthen Friary ...	4.03	104
"	Ponzaux, Morrah Gdn.	3.18	84	<i>Pemb.</i>	Haverfordwest, School	5.06	110
"	St. Austell, Trevarna...	3.22	75	<i>Card.</i>	Aberystwyth .....	4.05	...
<i>Som.</i>	Chewton Mendip .....	3.63	94	<i>Rad.</i>	Birm. W. W. Tynmynydd	6.00	95
"	Long Ashton .....	3.50	129	<i>Mont.</i>	Lake Vyrnwy.....	5.67	100
"	Street, Millfield.....	2.25	93	<i>Flint.</i>	Sealand Aerodrome ...	1.83	67
<i>Glos.</i>	Blockley .....	2.43	...	<i>Mer.</i>	Dolgelley, Bontddu ...	7.65	134
"	Gloucester, Gwynfa ...	2.20	91	<i>Carm.</i>	Llandudno .....	3.18	123
<i>Herc.</i>	Ross, Brethlen .....	2.55	106	"	Snowdon, L. Llydaw	10.20	120
"	Leadbury, Underdown...	1.92	87	<i>Ang.</i>	Holyhead, Salt Island	3.93	135
<i>Salop.</i>	Church Stretton.....	2.47	97	"	Lligwy .....	5.00	...
"	Shifnal, Hatton Grange	1.77	91	<i>Isle of Man</i>			
<i>Staffs.</i>	Market Drayt'n, Old Sp.	1.40	98	"	Douglas, Boro' Cem. ...	3.98	117
<i>Worc.</i>	Ombersley, Holt Lock	1.72	90	<i>Guernsey</i>			
<i>War.</i>	Birmingham, Edgbaston	1.92	95		St. Peter P't, Grange Rd	3.22	110

## Rainfall: January, 1933: Scotland and Ireland.

Co.	STATION	In.	Per- cent of Av.	Co.	STATION	In.	Per- cent of Av.
<i>Wigt.</i>	Pt. William, Monreith	3·65	112	<i>South</i>	Melvieh .....	2·07	63
"	New Luce School .....	2·06	78	"	Loch More, Achlary...	8·23	113
<i>Kirk.</i>	Dalry, Glendaroch .....	5·13	92	<i>Caith.</i>	Wick .....	1·70	72
"	Carsphairn, Shiel .....	10·12	153	<i>Ork.</i>	Pomona, Doorness .....	2·19	63
<i>Dumf.</i>	Dumfries, Orkilton, R.I.	5·33	174	<i>Shet.</i>	Lerwick .....	3·97	51
"	Esksdalemuir Obs. ....	7·75	144	<i>Cork</i>	Oaheragh Rectory .....	4·80	...
<i>Roeb.</i>	Bransholm .....	4·90	170	"	Cahanway Rectory .....	6·32	78
<i>Selk.</i>	Ettreik Mause .....	10·18	215	"	Cork, University Coll.	3·68	80
<i>Perth.</i>	West Linton .....	4·10	...	"	Ballinacra .....	3·43	80
<i>Berv.</i>	Marchmont House .....	1·32	59	<i>Kerry.</i>	Valentia Obsy .....	5·09	101
<i>E.Lot.</i>	North Berwick Ros. ....	1·24	72	"	Generalhamon .....	...	...
<i>Midl.</i>	Edinburgh, Roy. Obs.	2·59	147	"	Killarney Asylum .....	8·83	140
<i>Lon.</i>	Auchtyfardo .....	4·73	...	"	Darvynano Abbey .....	3·01	78
<i>Ayr.</i>	Kilmarnock, Kay Pk. ....	...	...	<i>Wat.</i>	Waterford, Gortmore...	3·71	102
"	Girvan, Pinnore .....	4·35	92	<i>Tip.</i>	Nenagh, Cas. Lough ..	4·51	114
<i>Renf.</i>	Glasgow, Queen's Pk. ....	4·05	121	"	Roscrea, Timoney Park	2·10	...
"	Greenock, Prospect H. ....	3·64	120	"	Cashol, Ballinamona ...	2·30	68
<i>Bute.</i>	Rothsney, Ardeneralg. ....	5·34	...	<i>Lim.</i>	Foynes, Coolmanes .....	3·80	105
"	Douglas Lodge .....	4·22	...	"	Castleconnel Rec. ....	2·81	...
<i>Arg.</i>	Ardgour House .....	12·50	...	<i>Clare.</i>	Inagh, Mount Callan...	...	...
"	Glen Etive .....	11·83	108	"	Broadford, Hurdlest'n.	4·21	...
"	Oban .....	9·27	115	<i>Wexf.</i>	Gorey, Courtown Ho...	2·09	93
"	Portlalloch .....	5·51	110	<i>Kilk.</i>	Kilkenny Castle .....	2·17	88
"	Inveraray Castle .....	9·50	110	<i>Wick.</i>	Rathnew, Clonmannon ...	2·06	...
"	Islay, Ballabus .....	4·21	90	<i>Carl.</i>	Hacketstown Rectory..	2·14	60
"	Mull, Benmore .....	9·80	...	<i>Leic.</i>	Blandsfort House .....	2·59	79
"	Tiree .....	4·24	100	"	Mountmellick .....	3·40	...
<i>Kinn.</i>	Loch Laven Sluice .....	3·43	109	<i>Offaly.</i>	Birr Castle .....	2·80	101
<i>Perth.</i>	Loch Dhu .....	10·20	112	<i>Kildr.</i>	Monasteravin .....	...	...
"	Balquhiddor, Stronvar	4·04	...	<i>Dublin</i>	Dublin, FitzWm. Sq. ...	1·34	59
"	Orkist, Strathearn Hyd.	4·63	112	"	Balbriggan, Ardgillan.	1·08	73
"	Blair Castle Gardens...	4·40	134	<i>Meath.</i>	Beauparc, St. Cloud ..	2·46	...
<i>Angus.</i>	Kottins School .....	2·08	79	"	Kells, Headfort .....	3·24	103
"	Pearse House .....	3·31	...	<i>W. M.</i>	Moate, Coolators .....	3·03	...
"	Montruse, Sunnyside...	2·01	101	"	Mullingar, Belvedere...	3·09	96
<i>Aber.</i>	Braemar, Bank .....	4·51	141	<i>Long.</i>	Castle Forbes Gdns. ...	3·03	118
"	Logie Coldstone Sch. ....	1·03	74	<i>Gal.</i>	Ballynahinch Castle...	0·19	99
"	Aberdeen, King's Coll.	1·82	83	"	Galway, Grammar Sch.	...	...
"	Fyvie Castle .....	1·08	71	<i>Mayo.</i>	Mallaranny .....	7·78	...
<i>Moray.</i>	Gordon Castle .....	·09	49	"	Westport House .....	3·47	96
"	Grantown-on-Spey .....	1·04	68	"	Delphi Lodge .....	11·03	117
<i>Nairn.</i>	Nairn .....	1·31	60	<i>Sligo.</i>	Markree Obsy .....	4·14	100
<i>Inver.</i>	Ben Alder Lodge .....	3·16	...	<i>Cavan.</i>	Belturbet, Oloverhill...	...	...
"	Kingussie, The Birches	4·13	...	<i>Ferm.</i>	Enniskillen, Portora...	3·12	...
"	Loch Quoich, Loan .....	15·80	...	<i>Arm.</i>	Armagh Obsy .....	2·13	85
"	Glanquoich .....	15·48	112	<i>Down.</i>	Fofany Reservoir .....	4·74	...
"	Inverness, Culdathol R.	2·78	...	"	Sonfords .....	2·51	80
"	Arisaig, Fairo-na-Squir	4·04	...	"	Donaghadee, O. Stn. ...	2·01	79
"	Fort William, Glasdrum	11·41	...	"	Banbridge, Milltown...	1·00	85
"	Skye, Dunvogan .....	7·01	...	<i>Antr.</i>	Belfast, Cavehill Rd. ...	2·30	...
"	Barra, Skallary .....	5·09	...	"	Aldergrove Aerodrome	1·77	65
<i>R &amp; O.</i>	Alness, Ardross Castle	3·18	84	"	Ballymena, Maryville	2·58	70
"	Ullapool .....	0·47	141	<i>Lon.</i>	Londonderry, Creggan	4·17	116
"	Achnashellach .....	0·94	103	<i>Tip.</i>	Omagh, Edensel .....	0·80	107
"	Stornoway .....	5·07	110	<i>Don.</i>	Malin Head .....	3·81	...
<i>South.</i>	Lahg .....	2·19	87	"	Millford, The Manse ...	4·01	107
"	Tangue .....	3·11	79	"	Killybegs, Rockmount.	3·87	99

## Climatological Table for the British Empire, August, 1932

STATIONS	PRESSURE		TEMPERATURE						Relative Humidity	Mean Cloud amt	PRECIPITATION		BRIGHT SUNSHINE		
	Mean of Day M.S.L.	Diff. from Normal	Absolute		Mean Values			Mean			Amt. in.	Diff. from Normal	Days	Hours per day	Per- cent- age of possible
			Max.	Min.	Max.	Min.	Diff. from Normal		Wet Bulb						
										° F.					
London, Kew Obsy.	1015.9	+ 3.6	92	52	75.2	57.9	66.5	+ 4.9	59.0	86	7.5	1.16	7	6.3	44
Gibraltar	1016.5	- 0.2	91	63	82.8	66.7	74.7	- 1.3	65.1	82	3.4	0.00	0	..	..
Malta	1017.4	+ 2.6	92	68	88.6	72.1	77.9	- 1.2	71.3	72	1.3	0.00	0	12.1	89
St. Helena	1016.7	+ 0.1	62	52	59.9	53.6	56.7	- 0.7	54.2	93	8.8	1.08	7	..	..
Sierra Leone	1015.1	+ 2.4	85	68	80.9	72.6	76.7	- 1.2	74.2	89	8.8	16.06	23	..	..
Lagos, Nigeria	1013.7	+ 0.7	83	68	80.8	72.8	76.8	- 1.1	72.5	85	9.3	3.02	8	4.7	38
Kaduna, Nigeria	1014.1	+ 1.0	87	53	81.4	64.1	72.7	- 1.2	69.8	87	8.8	10.03	17	4.0	32
Zomba, Nyasaland	1016.6	- 0.2	83	47	74.4	52.3	63.3	- 1.6	..	64	4.8	0.31	2	..	..
Salisbury, Rhodesia	1020.6	- 0.1	78	38	70.5	45.2	57.9	- 2.3	49.5	49	1.7	1.78	4	8.5	74
Cape Town	1020.8	+ 0.5	86	41	65.6	48.7	57.1	+ 1.5	50.4	89	5.6	2.51	12	..	..
Johannesburg	1020.4	+ 1.2	77	36	67.8	45.7	56.7	+ 2.3	41.5	25	0.2	0.00	0	10.5	94
Mauritius	1020.3	- 0.2	78	54	75.7	62.8	69.3	+ 0.3	65.7	70	5.6	1.06	21	7.7	69
Calcutta, Alipore Obsy.	1002.7	+ 1.7	93	76	88.4	79.0	83.7	+ 0.5	79.5	91	8.1	8.83	18*	..	..
Bombay	1006.0	+ 0.1	90	75	86.2	77.2	81.7	+ 0.3	77.3	87	8.0	6.96	17*	..	..
Madras	1005.8	+ 0.3	98	73	91.4	78.1	84.7	- 1.3	77.5	77	8.9	1.98	6*	..	..
Colombo, Ceylon	1008.7	- 0.6	86	71	84.8	75.8	80.3	- 0.9	76.8	82	7.5	15.99	25	5.0	41
Singapore	1009.1	- 0.4	90	72	86.5	74.9	80.7	- 0.4	76.9	83	6.6	3.54	19	6.0	50
Hongkong	1005.6	+ 0.8	91	74	86.5	79.0	82.7	+ 0.6	78.4	85	7.3	20.89	22	6.3	49
Sandakan	..	..	90	80	87.2	75.0	81.1	- 0.7	77.9	86	6.1	6.11	16	..	..
Sydney, N.S.W.	1018.7	+ 0.5	80	41	65.4	47.3	56.3	+ 1.3	50.4	71	4.3	2.31	13	6.8	62
Melbourne	1018.2	+ 0.2	67	33	57.9	42.5	50.2	- 0.8	46.0	78	7.1	3.26	21	3.8	36
Adelaide	1018.6	- 0.7	76	38	61.4	45.8	53.4	- 1.5	48.9	73	7.0	2.89	19	4.3	40
Perth, W. Australia	1018.7	- 0.2	77	41	61.4	47.3	54.3	- 1.7	49.4	73	6.2	6.13	21	5.6	51
Coalgate	1019.0	- 0.3	72	35	61.4	47.1	51.2	- 2.4	45.7	69	3.3	2.92	11	..	..
Brisbane	1020.7	+ 1.5	80	41	70.7	49.7	60.2	- 0.2	53.5	63	3.3	0.37	3	8.5	76
Hobart, Tasmania	1014.9	+ 1.5	64	32	51.8	41.6	48.2	+ 0.2	44.0	73	7.0	4.59	17	4.0	38
Wellington, N.Z.	1022.0	+ 6.9	59	32	50.5	39.8	45.1	- 0.5	43.0	77	8.3	6.67	16	4.7	45
Suva, Fiji	1015.2	+ 1.0	83	65	78.0	69.0	73.5	- 0.1	69.8	82	7.4	9.23	19	3.7	32
Apia, Samoa	1011.3	- 0.4	87	68	84.9	73.4	79.1	+ 1.3	75.5	77	3.7	5.99	13	8.3	71
Kingston, Jamaica	1012.4	- 1.1	92	70	89.0	73.8	81.4	- 0.1	72.9	81	4.0	2.94	11	8.3	65
Grenada, W.I.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Toronto	1014.6	- 0.8	95	51	79.3	59.9	69.6	+ 2.4	63.4	78	3.2	4.17	13	8.9	64
Winnipeg	1013.7	+ 6.5	91	40	79.6	53.1	67.3	+ 2.5	55.4	99	4.4	1.53	8	9.5	66
St. John, N.B.	1014.6	- 3.4	77	52	70.0	46.2	53.1	+ 2.3	59.8	89	6.6	3.56	17	6.8	48
Victoria, B.C.	1015.7	- 1.6	88	59	65.9	52.4	59.1	- 0.6	55.3	80	5.3	9.90	6	8.5	62

\* For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen.

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## The Great Snowstorms of February, 1933

CONTRIBUTED BY THE FORECAST DIVISION, METEOROLOGICAL  
OFFICE

A series of intense and prolonged snowstorms, one of the worst within living memory, occurred in most districts of the British Isles during the period Thursday, February 23rd to Sunday, February 26th, 1933, and it is proposed to give a preliminary account of the storms and of their meteorological aspects.

According to the daily Press the storms were the worst experienced since the well-known snowstorms of January 17th-21st, 1881. It will not be possible to confirm that opinion until further information regarding the recent storms has been received. The snowfall on January 18th, 1881, was so severe as completely to cut-off the milk supply of London. That day has become known as "Black Tuesday."

From the meteorological point of view the two series of storms were quite unlike one another, and the distribution of snowfall was also different in the two cases. The depression which was associated with the 1881 storm was an "Atlantic" depression, of the type which has been so intensively studied during recent years by the Norwegian School of Meteorologists; that is to say it had a well-marked "warm sector" on its southern side, consisting of air which had been drawn from low latitudes over the Atlantic. The depression was centred near the Channel Islands on the morning of January 18th, and it travelled slowly but steadily eastwards along the Channel along a well-defined

track.\* An article in *British Rainfall*, 1881, by Sowerby Wallis, describes the effects of the storm. The snow on that occasion fell continuously during the 18th until about noon on the 19th in an easterly gale at a temperature which for the most part was much below freezing point. In consequence the snow was very fine and dry, and was rapidly blown into deep drifts in railway cuttings, roads, etc., with the result that railway and postal services were disorganised for the greater part of a week. The area of the intense snowfall was limited to the area south of an irregular line from Liverpool to Flamborough, over a considerable part of which a quantity of snow equivalent to an undisturbed depth of at least a foot is estimated to have fallen.

The recent storms were of an entirely different character. Following a period during which pressure was high to the west of the British Isles, there occurred on about February 17th an extension northwards to Iceland of the high pressure system which brought down a steady supply of cold air from the Arctic Sea. The whole of the British Isles was covered with this polar air on Thursday morning, February 23rd, when, in spite of the fact that the current was apparently homogeneous and cold up to considerable heights a general fall of the barometer was seen to be in progress, especially in northern districts. At 11 p.m. on February 23rd a small centre of low pressure was situated over the extreme north of Ireland, and a feeble cyclonic circulation was set up around it, with some falls of snow and sleet in the north of Ireland. This disturbance was embedded in the general current of polar air, and at the surface there was no equatorial air within many hundreds of miles. It was at once recognized that here was one of those mysterious "depressions in polar air" the nature of which is at present obscure. The forecasting of the subsequent history of these disturbances is a matter of great uncertainty; but in this case it seemed clear that the system would deepen and continue to move slowly southwards in the general northerly wind, and that appreciable falls of snow would occur. The following forecast was accordingly supplied to the B.B.C. for broadcasting at 6 p.m.

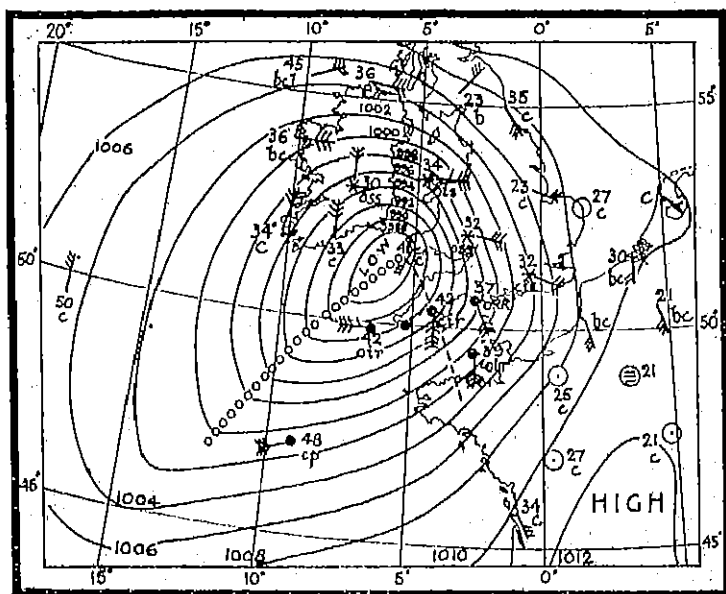
*Weather Forecast for to-night and to-morrow.*—A complex low pressure system is developing over the British Isles and the North Sea, and the most important centre is moving slowly southward over Ireland and deepening considerably. Snow is expected in many parts of the country, and road traffic is likely to be affected in several districts. In Ireland, Wales, and south-west England there will be heavy snowfall inland to-night, but there will be sleet or rain near the south-west seaboard. In Scotland and northern England there will be occasional snow,

\* See "Forecasting Weather," 2nd Edition, p. 100, for a weather map of this snowstorm.

especially near the east Coast. In south-east England and the Midlands weather will be fine at first with sharp frost and local fog, but there is a considerable likelihood of snow to-morrow.

*Outlook for Saturday.*—Wintery weather continuing, with snow at times in many districts.

Reference to dislocation of road traffic on account of weather conditions is a new departure in weather forecasts, and but for the proverbial difficulty in predicting the amount of snow-fall, the reference would have been more decidedly, and, as it transpired, even more accurately worded than it was. By next morning at 7 a.m. the depression had deepened considerably; it was centred at the entrance to St. George's Channel and the cyclonic circulation embraced the whole of the British Isles. A weather chart for this period is reproduced. On this chart



SYNOPTIC CHART 7h. FRIDAY, FEBRUARY 24th, 1933

Quasi warm front is indicated by - - - - -  
Quasi cold front is indicated by ooooooooooooo

are shown a "warm" front and a "cold" front, but these fronts cannot be regarded as at all typical, for the air in the sector between them, though rather warmer than that outside the sector, was definitely of polar origin. It had, however, come from the Atlantic just to the west of Ireland, where it is seen that temperatures reported from ships were at about 50°F. The area of the sector between the warm and cold fronts probably provided the avenue whereby the water vapour, which was then

falling as snow over the west of England and over Wales, was finding its way into the depression. It seems likely that no great development of this kind could have occurred in the polar air but for the fact that this relatively warm and humid "maritime polar" air from the Atlantic had been drawn into the circulation. Probably the detailed structure of the depression was more complex than might be gathered from the drawing of simple warm and cold fronts. The warm sector proved misleading as a guide to the subsequent motion of the system. Actually the centre moved slowly westward to a position off south-west Ireland, the total westward movement in 48 hours being fully 450 miles. This led to an immediate thaw in southern England, which spread slowly over the whole of the British Isles. Depressions which develop in polar air have a marked tendency to move in a slow irregular manner. They have fairly frequently caused snowstorms in the past, notably in March, 1909 and 1916, and April, 1908, 1917 and 1919. The development of March 5th to 8th, 1909, showed some resemblance to that of February 23rd to 26th, 1933. The majority of recent cold spells have been of easterly rather than of northerly type, and have led to no developments of the kind we are discussing. On February 28th-29th, 1924, there was an extreme development in polar air off northern Scotland, pressure falling to 960 mb. at the centre, and there was a very severe snowstorm in northern Scotland and a lesser storm elsewhere. If polar-air depressions grow to any size they are apt to become stationary sufficiently far west to cut off the direct supply of polar air to the British Isles, and so cause a thaw, at least on the low ground.

In the recent case the pressure at the centre of the disturbance was about 1,006 mb. on the evening of the 23rd and 986 mb. next morning, and for the following two days. It is perhaps worth remarking on the apparent tendency for a greater deepening by night than by day.\* The three-dimensional structure of polar air depressions is a matter for research in the future, but meanwhile there are certain known facts to which attention may be called. The features normally found over European depressions, namely, a cold troposphere, low pressure in the upper troposphere, and a low and warm stratosphere, are also found in well-marked polar currents, and thus probably exist before a polar air depression forms. If the lapse-rate of temperature in the troposphere is sufficiently unstable for saturated air, there is a possibility of a large fall of surface pressure being caused by the ascent of warm damp air. If pressure remains unchanged at 8 kilometres and the mean temperature of the column of air up to that level rises 10° F., then surface pressure falls about 22 mb.

\* \* \* \* \*

For a more detailed account of the snowstorm in different

\* See *Meteorological Magazine* 60, 1931, p. 39.

districts, we may consider firstly the northerly spell preceding the main storm, then the storm of the 23rd-24th, and finally the later phases. The northerly spell began when a ridge of high pressure moved south-east from Greenland on February 10th and formed into a large stationary anticyclone off west Ireland, but really wintry weather only commenced on the 17th, when pressure became highest in east Greenland. From that day onwards snow fell daily in some part of the country, mainly in the form of showers. As usual in a northerly type, the districts most affected were northern Scotland, north Wales, north-east England and the eastern coastal zone. Instability showers are formed when a cold current crosses a warm sea, and these drift a short distance inland and are intensified by orographic features or by convergence of surface winds at a coast line.\* Instability showers do not form readily over land in winter, so that most of southern England escapes lightly with northerly winds. Most of the Scottish Lowlands are effectively screened by the Highlands. On the night of the 21st there was a moderately heavy snowfall in Norfolk, Suffolk, and east Kent, and in the latter region several roads were blocked with drifts, which were reported in the Press to be seven feet deep in some cases.

The main storm commenced in Ireland and Wales on the evening of the 23rd, and was continuous for more than 24 hours over the greater part of both countries (with the exception of the north) and drifted in an easterly wind which increased to gale force. During the night of the 23rd a rainfall equivalent of 1.69 in. fell at Pembroke. Over a considerable area in south Wales the local fall probably reached or exceeded two feet. Many villages were isolated, and railway traffic was badly delayed, the Irish Mail from Fishguard arriving at Paddington 13 hours late. Many telegraph wires were broken down by the weight of snow, and photographs in the Press showed the wet nature of the snow near the south coast of Wales. In Wales and Ireland the statements in the Press that the storm was the worst for 50 years were quite probably justified. A letter from Hacketstown Rectory, Co. Carlow, reports a "record" snowfall with numerous 6- to 10-foot drifts. Over most of southern England the storm was less severe than that of December, 1927. It was, however, severe over a large area in the south-west, though on the south coast only sleet and rain were reported. During the 24th the storm spread eastward, and then extended northward slightly beyond the Scottish border, and included northern Ireland. A fair degree of severity was maintained in the Midlands and north, and trains were delayed by heavy drifting, which was helped by the fact that the temperature was still below the freezing point. Towards the east the severity of the storm fell off rapidly, and the east coast had

\* See *London Q.J.R. Meteor. Soc.* 48, 1922, p. 357.



little snow. In London there was a moderate fall which lay on open spaces, but had almost disappeared by next morning.

On the 25th and 26th there was sleet and rain in the south, but further considerable snowfall in many other districts. The change from rain and sleet to snow took place surprisingly far south, considering the strength of the south-easterly wind. It was not only a question of height above sea level, since snow fell on low ground also, for example at Ross-on-Wye at 7h. on the 26th, and also at Cranwell, where 8 inches were lying. At 13h. on that day it was still snowing at Birmingham. No doubt the air at low levels was quickly cooled as it penetrated inland, both by the snow on the ground and by snow falling into the surface layer from above.

In Yorkshire the fall was heavy and continued till the evening of the 26th, when no less than 28 inches were lying at Harrogate. Conditions were already severe in this region before the main storm, and the total snowfall was probably as heavy as in south Wales. A number of villages were isolated in Yorkshire and Derbyshire. At Buxton the average depth was estimated to be fully two feet.

The total precipitation in the three days was large, especially in southern districts and in Yorkshire, and illustrates the possibilities of maritime polar air. At Stonor Hill, Petersfield, there was continuous precipitation from 7 a.m. on the 24th until 8 a.m. on the 27th, with the exception of two intervals of 3 and 2 hours respectively. The total amount for the rainfall days 24th to 26th was 4.35 inches. Other large aggregates for this period were 4.74 inches at Solbourne (Hants), 4.12 inches at Hoddington (Hants) and Harrogate, 3.38 inches at Winchester, 3.31 inches at Boscombe Down, 2.75 inches at Ross and South Farnborough, and 2.79 inches at Ilkley. Rain and melting snow caused flooding in several districts, including the Thames Valley.

Thunderstorms occurred locally in south-west districts on the 25th and again on the night of the 27th and on the 28th. Gales occurred on most coasts between the 24th and 26th. Calshot recorded a gust of 85 m.p.h. during the morning of the 24th, and another of 81 m.p.h. early on the following morning.

### **The Snowstorm in Breconshire**

The snowfall here on February 24th was a record for more than 20 years. All roads were completely impassable to traffic. Towns in the hills had huge drifts 10 and 14 ft. deep in places. I registered 1.61 inch in the rain-gauge—the snow was 18 inches on the level in the valley. I was up on the mountains all that morning with local farmers looking for sheep and, although I am about in all weathers, never remember anything like the conditions. The wind was terrific and the drift absolutely

choking—it was so bad that one could only see about 20 yards and we were forced to shelter in the rocks on the way down as one couldn't face the drift without choking. I estimated the wind on the summit of the mountain as about Force 9, in the valley only Force 7. All the sheep were smothered and we had to leave them and shelter ourselves. We were almost snowed up when we ventured back, the drifts being 16 feet in the hollows, and it took us nearly  $4\frac{1}{2}$  hours to go three miles. I think we were lucky to get back.

R. G. SANDEMAN.

*Dan-y-Parc, Crickhowell, Breconshire. March 2nd, 1938.*

## Electrical Discharge from an Elevated Point during the Thunderstorm of February 10th, 1933

By L. H. STARR, M.Sc.

For some months a continuous record has been obtained of any electrical discharge from a needle point fixed at the top of a pole, thirty feet high, situated in the paddock at Kew Observatory. By means of insulated cable, the needle point is connected to one terminal of a galvanometer, the other terminal of which is earthed. Movements of the galvanometer coil, due to currents entering or leaving the point, are recorded photographically on a traversing clock drum rotating once every two hours. Minute and hour marks are added by the intermittent lighting of a small lamp, which is switched on by a relay in the circuit of the Morrison clock. Thus, for a normal day, the record consists of a series of twelve straight lines with short transverse time marks. Any deviation, due to discharge current can be readily detected. Point discharge does not in general commence until a certain minimum gradient of potential is exceeded. It is believed that the critical gradient is that which maintains at the point a field, which causes electrons or ions approaching the point to accelerate to a velocity at which they ionise the air through which they pass. With our thirty-foot pole, the potential gradient "in the open," which must be surpassed to produce discharge is approximately 1,200 volts per metre. The record is arranged so that strong positive (*i.e.*, normal) potential gradient causes a deflection above the zero line. This corresponds with a capture of positive ions or with a discharge of electrons from the point. A deflection below zero occurs in strong negative fields and represents a capture of negative ions or electrons by the point.

The illustration on pages 36 and 37 is a reproduction of the record obtained during the thunderstorm of February 10th. In the original the records for successive periods of two hours



WIND VEERING TO E.

Rain moderating slightly.



Rain abating.



Rain ceased.



POINT DISCHARGE RECORD, KEW OBSERVATORY, FEBRUARY 10TH, 1883.

Time scale of actual record : 1 hour = 36 cm.

Calibration of galvanometer : 1 cm. = 4.8 micro-amperes.

overlapped. The value of the deflections in micro-amperes is given and a second scale shows the potential gradient at ground level corresponding to different values of discharge current. The scale of potential gradient was deduced from the simultaneous record of an electrograph designed for recording strong fields. Time marks, except those at the hour and ten-minute intervals, have been omitted in the reproduction. The sudden discontinuities in the record are associated with lightning flashes. When available, the number of seconds in the interval between the lightning and the subsequent thunder has been inserted. All times are G.M.T.

The first development of the storm was observed to the west of the Observatory, at about 14h. 10m.; the storm centre passed to the south and, by 15h. 20m., it had retreated to south-east, the nearest point on its track being a little over a mile to south-south-west. Heavy rain could be seen below the cloud base, but a few drops only fell near the Observatory. All lightning observed was between cloud and ground, and the flashes were most frequent from 14h. 30m. to 14h. 50m. A few of the recorded flashes were not observed. At 15h. 34m., when the main storm was approaching slowly from the north, another cloud, situated less than half a mile away, gave a single lightning flash. Sparks were observed inside the Observatory in two rooms; in one the spark was from the lead-in of the telephone, in the other from that of the wireless set. Thunder was almost immediate. The discharge record indicates that the electrification of this cloud, and possibly of other nearby clouds, must have continued to be considerable, but attention was now focussed on the approaching storm to the north and no special note was made of these clouds. Reflections from lightning to the north were first observed at 16h. 5m. and these increased rapidly in intensity, recurring at intervals of four to six minutes. Although no direct lightning tracks were visible, the last flashes at 16h. 30m. and 16h. 34m. appeared to reach overhead and to be about one mile distant. No further lightning occurred, but the rain, which had been slight and intermittent during the first storm, and slowly increasing during the approach of the main development, now became torrential, and continued so with squalls until 17h. 15m., afterwards moderating slowly to cease at 19h. 15m.

If the record is now examined, it will be seen that the point discharge and corresponding field changes were fairly straightforward during the initial storm. Discharge, indicating a high positive gradient, commenced while the active centre of the cloud was some three or four miles away. As the cloud approached, discharge ceased except for shortlived disturbances caused by lightning, which produced temporarily intense positive fields. A negative field followed with large positive changes accompanying

lightning. As the cloud passed to south-east, a high positive field returned and subsequently the field diminished until the discharge ceased for a few minutes.

It will be seen that the single flash at 15h. 34m., the one which produced sparks inside the observatory, occurred during a period of high positive field and produced an intense reversal temporarily; a still higher positive value was rapidly assumed. The fields due to this, and possibly to other local clouds, which were not carefully observed, masked electrically the approach of the main storm, but the discharge with positive fields at about 15h. 55m. and the single lightning flash at 15h. 59m. are probably due to the latter. A reversal of field followed and, although no actual lightning tracks were visible, the record shows at each flash a positive change of field, small in the case of those between 16h. and 16h. 10m. but later much larger and preceded occasionally by a reversal from a negative value to a positive value. The last of these flashes was at 16h. 34m. The outstanding feature of the record is, however, the intense negative gradient, at times reaching 20,000 volts per metre, which occurred during the very heavy rain. The maximum discharge current, recorded at 16h. 56m., was 16 micro-amperes. Subsequent discharges were of a very complex character and continued until the rain abated at 19h.

The practice has been adopted of estimating the quantity of electricity passing through the needle point in periods of two hours. The unit is the millicoulomb, which is the quantity carried by a current of one micro-ampère flowing for 10 $\frac{2}{3}$  minutes. For the storm of February 10th, the integrated quantities flowing into and out of the needle point are shown in the following table:—

<i>Time.</i>	<i>Quantities flowing</i>	
	<i>Into Point</i>	<i>Out of Point</i>
	<i>millicoulombs.</i>	
14h.-16h. ... ..	2.20	1.71
16h.-18h. ... ..	2.23	16.64
18h.-20h. ... ..	1.61	1.62

The net discharge for the whole storm is 13.93 millicoulombs out of the point.

Any final discussion of the meaning of such a record as this cannot yet be undertaken. Attention may, however, be drawn to the relation between surface potential gradient and lightning. It might have been anticipated that the usual effect of lightning would be to reduce the strength of the electric field. It will be seen from the record that this is by no means the case. Very intense fields at the earth's surface do not precede lightning; they appear to be produced by it. But these intense fields are shortlived and a field nearly equal to that existing before the

lightning is generally established after about fifteen seconds. Further, the most intense steady surface-gradients are not generally accompanied by lightning; they occur during vigorous precipitation.

The investigation has been undertaken to estimate the importance of point discharge as a component of air-earth current. From the record described above, it would appear that the information afforded concerning potential gradient may prove of even greater interest.

## The Beginning of Spring

A note in the "Calendar of Nature Topics"\* a few weeks ago remarked on the proverbial association of the beginning of spring with St. Valentine's day. This is five weeks earlier than the astronomical beginning of spring. Even in a notoriously fickle climate this seems an unnecessarily large discrepancy and some consideration is suggested of the question when spring may be said, on the average, to begin.

Spring is defined by the *Oxford Dictionary* as the "season in which vegetation begins, season preceding summer (esp. from about March 21st to June 22nd)."

In the meteorological calendar spring begins on March 1st and includes the months of March, April and May. This definition has two obvious advantages; it gives to spring almost exactly one quarter of the year, and the coincidence with the calendar months greatly facilitates the computation of "seasonal" averages. The astronomical definition of spring as the period between the spring equinox and the summer solstice retains the former advantage but discards the latter; moreover, it seems a contradiction to include the longest day of the year—"midsummer day," at the end of spring. Nature however does not—in this instance—proceed by fixed quanta, and it is an interesting subject of discussion which definition of spring best fits "the season in which vegetation begins." The beginning of vegetation is, however, an extremely vague date. The snowdrop blooms in January and the crocus is associated with St. Valentine.

In western Europe phenological charts have been used for 50 years or more to show the march of spring northward and eastward, an early example showing a period of over 72 days required for the progress of spring from the shores of the Gulf of Corinth to northern Norway. A more recent investigation† shows that in 1930 the beginning of spring was 72 days later in Hammerfest than in Palermo. These "spring charts" are based on observations of dates of the earliest flowering of various

\* Nature, London, 191, 1933, p. 214.

† "Der Frühlingsbeginn am Zürichsee" von Hans Frey (Klitenacht), Neujahrsbl. Nat. Ges. Zurich, 1931.

plants, and a difficulty lies in finding a representative selection of plants which can cover a large enough range of latitude, also the appearance of the selected flowers does not necessarily give the season in which vegetation begins. The temperature of  $6^{\circ}\text{C}$ . or approximately  $42^{\circ}\text{F}$ . is supposed to be of significance for plant life; it was regarded by continental botanists of the last century as the critical temperature above which the growth of vegetation begins and is maintained in a European climate, and  $42^{\circ}\text{F}$ . was chosen as the base line temperature for the computation of "accumulated" temperature.

A convenient meteorological date for the beginning of spring therefore might be that on which the smoothed curve of the annual course of temperature rises above  $42^{\circ}\text{F}$ . The data for Kew Observatory, which from a previous investigation\* are in suitable form may be examined from this point of view. It appears that the smoothed curve of the temperature for the period 1871-1929 passes above the  $42^{\circ}$  line on March 11th, whereas for 1871-1900 the date is March 17th, and for 1901-1929, March 2nd; thus in the second period spring was 15 days earlier than in the first. There are no comparable phenological data for the whole period in question, but the table compiled by Messrs. Clark and Margary,† which shows the average date of flowering of 13 plants in a 35-year period, is of interest. This table shows that the average date for all districts was three days earlier in 1916-1925 than in 1891-1900. If only the five districts with the longest records are considered the apparent advance of the flowering season is reduced to one day. Temperature is only one of the numerous factors affecting the phenological events, and in 1893, when the earliest spring recorded by the phenologists occurred, the early part of the year was less noteworthy with regard to temperature than to the other meteorological elements. The study of weather in relation to plant life is one in which much remains to be done. In particular, it is not known to what extent duration of daylight is important, irrespective of temperature.

The problem is simplified in those countries where some spectacular natural event such as the débacle or break-up of ice in the rivers makes an obvious end to the rigours of winter. In southern Russia and southern Canada this occurs about the middle of March, and since it nearly coincides with the disappearance of the snow cover and a rapid rise of temperature it is a highly appropriate herald of spring. Taking all these factors into consideration, we see that in our latitudes spring can hardly be said to open so early as March 1st. The weight of evidence seems to place the average date of commencement a few days later, but certainly earlier than the spring equinox.

\* London, *Q.J.R. Meteor. Soc.* LVI, 1930, p. 375.

† *Ibid.* p. 50.



The date varies widely from year to year, however, and in some years spring is certainly "in the air" by the end of February, while in other years it is delayed until April.

Bearing in mind the usual description of spring weather in this country as "treacherous," one is not surprised to find on reference to temperature data that the daily mean temperature appropriate to March 21st may be attained any time between January and May. It is not intended, however, to define the "treachery" of the weather as a matter of range of mean temperature—in the last 60 years at Kew Observatory the mean temperature for 24 hours on March 21st has varied between 53°F. and 29°F., a range of 24°, whilst July 15th has varied from 77°F. to 53°F. and February 15th from 53°F. to 21°F. Thus, if we attempt to improve on the astronomer's definition of spring as beginning on the same date all over the northern hemisphere, it is necessary to proceed with caution.

Since for meteorological purpose we need a fixed date, however, the convenience of including three complete calendar months is sufficient to outweigh the slight prematurity of March 1st, and we may allow spring to borrow a few days from winter.

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### Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, February 15th, at 49, Cromwell Road, South Kensington, Prof. S. Chapman, F.R.S., President, in the Chair.

The Presidential Address, which should have been delivered at the annual general meeting on January 18th, was postponed until this meeting owing to the illness of the President. Professor Chapman took as his subject "Atoms, Molecules and the Atmosphere."

While the molecular constitution of air can be ignored in considering most meteorological problems of the lower atmosphere, it is of great importance for the phenomena of the upper atmosphere. The remarkable advances made in recent years in our knowledge of the intimate constitution of matter bear closely on many problems of upper-atmospheric physics. For this reason a broad summary of modern views on atomic and molecular structure was given, bearing on their states of excitation, ionization and dissociation, on the spectra that they emit, and on the effects of impacts between particles of various kinds, electrons, atoms, molecules and ions. Brief mention was made of some atmospheric phenomena in which such considerations are of importance—the spectra of the aurora, and of absorption bands produced by oxygen, ozone and water; the dissociation of oxygen in the upper atmosphere; and the ionization of the upper air.

## Correspondence

To the Editor, *The Meteorological Magazine*.

### Curious Cirrus Cloud

The clouds described below were observed near Hindhead, Surrey, on January 6th. During the morning, light cirrus travelled over the sky from north-west, and at 10h. 15m. in the west about  $40^\circ$  up I saw two very well defined, roughly parallel cirrus bands. They were fibrous in texture, breaking at the east end into a faint cirro-cumulus structure. They had altered little by 10h. 45m., when observation was rendered impossible by proximity of the sun. The bands remained roughly parallel throughout. No other cloud than cirrus was seen that day until after noon. Aircraft were about between 10 and 11, but the duration and appearance of the cloud lead me to conclude that smoke was not responsible for the phenomenon:

S. E. ASHMORE.

22, Soho Road, Handsworth, Birmingham. January 8th, 1933.

### The Low Temperatures of January and February, 1933— their probable cause

The marked fall of temperature which occurred in the second fortnight of January over almost the whole of Europe, again raises the question of the probable cause of abnormal variations of temperature.

Though the immediate cause of these variations is the displacement of certain centres of high and low barometric pressure, which determines the direction of the winds, we cannot stop here, but must investigate the cause of these displacements of the great atmospheric centres of action; further, this cause must also explain variations of temperature, since with the same direction of the winds and almost the same barometric pressure the temperature may be very different; for example, from December 15th to 20th, 1932, with high pressure over central and western Europe, and low pressure centres over the Atlantic, the weather was very mild ( $64^\circ\text{F.}$  at Bordeaux on December 16th, 17th and 18th). On the other hand, from January 15th to 25th, 1933, with high pressure over Europe and low over the Atlantic, temperature was very low.

Thus, atmospheric conditions, being almost identical, cannot explain such differences of temperature as those between the second fortnight of December and the second fortnight of January; the cause cannot be found even in the wind direction, since in January east winds were cold but in December night temperature at Bordeaux with east winds was about  $45^\circ\text{F.}$  We must seek elsewhere.

Very curious coincidences occur between variations of tem-

perature on the one hand, and on the other, variations in the phenomena of the sun's surface, spots, faculae, etc., as observed daily at the Observatory of Talence for more than 30 years. Similar observations now cover a period of nearly 60 years, and have shown the following relationship between solar phenomena and the temperature of western Europe:

Every recrudescence of sunspots or of faculae is followed by a rise of temperature.

Inversely, every diminution of sunspots or of faculae is followed by a fall of temperature.

This is precisely the coincidence which occurred in December and January last. In December the appearance of large spots on the sun (one of which was visible to the naked eye from December 10th to 15th) was followed by relatively high temperatures, especially after a recurrence of the spots from December 18th to 20th. The latter, in consequence of the rotation of the sun in about 25 days, reappeared from January 3rd to 10th, but decreased after the 10th. Following this diminution and the complete disappearance of these spots after January 10th, temperature fell considerably over almost the whole of Europe and the western Mediterranean. There was a new formation of spots from January 26th to 28th, and another rise of temperature. These coincidences conform to the rule given above and bring out what might be described as the "individual action" of sunspots on our temperatures.

Another large group of spots was visible on the sun during the first fortnight of February and was accompanied by high temperatures. This group of spots disappeared on February 13th and temperature fell again. The table given below shows the variation of sunspots with temperature in our countries:—

	Number of Spots (Total of 5 days)	Temperature (Bordeaux) (Mean of 5 days)
1883. January 15th-20th	3	3.4
"    21st-25th	0	-2.0
"    26th-31st	6	6.7
February 1st-5th	16	11.2
"    6th-10th	16	11.6
"    11th-15th	5	5.2
"    16th-20th	0	2.8

These variations are similar to those of November and December. If the cause of the appearance and disappearance of the spots, faculae and other phenomena of the sun were known a method of forecasting, which is not possible at present, could be based on these phenomena.

Nevertheless, as the sun rotates in about 25 days we know that an immense group of spots which turned the western edge of the sun on February 12th and 13th will reappear on the eastern

edge on February 27th or 28th. There is therefore a great probability that temperature will rise at this time and that the first days of March will have relatively high temperatures. Consequently a return of cold is probable towards March 10th when these spots will disappear again, except for modifications caused by the appearance of new spots.

A periodicity of 100 years in the return of solar periods can give useful indications of the probable return of certain seasons after an interval of a century. Thus, the cold winter of 1929 corresponds with those of 1829 and 1729; the cool and rainy summer of 1927 corresponds with that of 1827; the unpleasant years 1930 to 1932, to 1830 to 1832, the hot August of 1932 to August, 1832, the cold January of 1933 to that of 1833, etc. This secular correspondence can be readily explained by the fact that a century comprises nine solar periods of an average length of 11.1 years; in spite of the unequal duration of solar cycles (ranging from 9 to 13 years), cycles of the same length recur at the same date from one century to another.

If these periods were rigorously similar from one century to another, one could announce that 1933 would present the same character as 1833, which was not a warm year, but this indication could only be precise if we knew the cause of the appearance and disappearance of phenomena on the surface of the sun. At least, we can say that the marked atmospheric variations which occurred during the first two months of winter have coincided with definite phenomena at the surface of the sun and indicate the real cause of these variations. It is to be regretted that the sun does not hold its rightful place in meteorological observations.

HENRI MIMERY.

*Observatoire de Talence (Gironde), January 31st and February 21st, 1938.*

## Reviews

*The effect of Indian Mountain Ranges on Air Motion.* By S. K. Banerji, D.Sc. (Reprinted for private circulation from Indian Journal of Physics, Vol. v, Part vii, pp. 699-745.) Calcutta University Press, 1931.

In an earlier paper, reviewed in this magazine last year, Dr. Banerji investigated the effect of the Indian mountain ranges on the sea-level isobars (assumed to be true stream lines for the level of about 0.5 Km.) during the months of the south-west monsoon. The present paper gives "a more detailed analysis of the various points that were only very briefly discussed in the first paper." With various simplifying assumptions, an extensive analysis is given by which the theoretical stream lines in the monsoon current can be drawn over India, and these stream lines are shown to agree closely with the "observed stream lines" at the 0.5 Km. level. It may be noted, however,

that if we take as "observed stream lines" at the 0.5 Km. level, the scheme recently given by Wagner,\* instead of the system of sea-level isobars, the agreement is not so close.

A short section is devoted to consideration of the vertical motions; the figure computed for the rainfall of June to September over the Western Ghats—7,600 inches—vastly exceeds any figures observed in India, even the celebrated Cherapunji having a mere 300 odd inches, in those four months, so that the utility of discussing a mean monsoon season is doubtful. In the further discussion promised, it is to be hoped that Dr. Banerji will concentrate his powerful analytical attack more on the three-dimensional aspects of the problem.

S. T. A. MERRILES.

### Books Received

*Monthly Rainfall of India for 1927, 1928 and 1929.* Published by the various Provincial Governments and issued by the Meteorological Department. Calcutta, 1929, 1930 and 1931.

### Obituary

*Captain Robert Lee Faris.*—We regret to learn of the death on October 5th, 1932, at Washington, D.C., of Capt. R. L. Faris, Assistant Director of the United States Coast and Geodetic Survey. Captain Faris was born at Caruthersville, Missouri, on January 13th, 1868, and received the degree of civil engineer from the University of Missouri in 1890. During the early part of his career he was mainly engaged on the extension of the trans-continental triangulation along the 39th parallel across the Rocky Mountains and on hydrographic work when he was in charge of magnetic observations at sea. From 1906-14 he was Inspector of Magnetic Work and Chief of the Division of Terrestrial Magnetism.

*Professor Harlan Wilbur Fisk.*—We regret to learn of the death, on December 26th of Prof. H. W. Fisk, Chief of the Section of Land Magnetic Survey in the Department of Terrestrial Magnetism of the Carnegie Institution. He was born at Geneva, Kansas, on September 25th, 1869, and after training in mathematics and astronomy he was appointed Professor of Mathematics at Fargo College, North Dakota. Here he became interested in terrestrial magnetism, and after some voluntary surveying work he joined the Department of Terrestrial Magnetism in October, 1906. His surveying activities included Bermuda and the West Indies, Central America and the northern parts of South America. He was also interested in the effect of eclipses on the earth's magnetic field and in secular variation. In 1929-32 he was secretary of the Section of Terrestrial Magnetism and Electricity in the American Geophysical Union.

\**Beitr. Geophysik, Leipzig*, Vol. 80, 1931, p. 106.

## News in Brief

The Fourteenth Annual Soirée of the Meteorological Office was held at the Royal Hotel, Woburn Place, London, on February 24th from 7 to 11.45 p.m. Despite the inclemency of the weather, a large and cheerful company assembled. The greater part of the time was occupied in dancing, and in addition there were games, prizes and a greatly appreciated entertainment by the well-known comedienues Elsie and Doris Waters. The ball-room lent itself readily to conversation, and in the short interludes between dances as well as in the refreshment interval, many scattered members of the staff—and their wives—were able to renew old acquaintance, while it was a great pleasure to welcome also a few former colleagues. The evening was generally voted a great success.

The twelfth annual dinner of the staff of the Meteorological Office, Shoeburyness, was held at the Queen's Hotel, Westcliff, on Saturday, February 18th, 1933.

## The Weather of February, 1933

Pressure was above normal over most of Russia, Spitsbergen, extreme north of Scandinavia, northern North Atlantic, most of the British Isles, Alaska, British Columbia, west and south United States and in the neighbourhood of Bermuda, the greatest excesses being 14.4mb. at Styckisholm, 14.2mb. at Julianhaab and 12.8mb. at Waigatz. Pressure was below normal over most of Canada, north-east United States, southern North Atlantic and most of Europe, the greatest deficits being 6.2mb. at Bornholm and 4.7mb. at 60° N., 110° W. Temperature was above normal in Spitsbergen and Scandinavia except in northern Lapland where it was as much as 5°F. below normal and below normal in central and south-west Europe. Precipitation was deficient in Spitsbergen and in excess in Switzerland; in Sweden it was 70 per cent. above normal in Scania and central Lapland and 40 per cent. below normal in Örebro, Skaraborg and Linköping.

The weather over the British Isles was mild at first, becoming cold about the 10th with severe snowstorms later. Sunshine records for the month were generally considerably above the normal. From the 1st to the 9th depressions passed to the north-west of the British Isles with associated secondaries and the weather was mild and unsettled with bright intervals. The 2nd was a sunny day over the whole country with 7.9 hrs. bright sunshine at Rothamsted, 7.7 hrs. at Dundee and Clacton and 7.6 hrs. at Stonyhurst. Rain occurred on most days, with snow, sleet or hail locally in Scotland on the 2nd, while gales were experienced in the north and west on the 2nd, 8th and 9th and

a thunderstorm at Lerwick on the 2nd. Mist or fog occurred locally. Maximum temperatures reached 58°F. at Nottingham, Cambridge, Hull, Dublin and Waterford, and minima exceeded 50°F. in south Ireland on one or two occasions. On the 10th, northerly winds in the rear of a large depression caused a marked fall of temperature to spread over the country, while a small secondary moving south-east across the British Isles brought snow and sleet showers generally in Scotland and during the night of the 10th-11th over eastern England as well. Thunderstorms were experienced at Tottenham, Kew and Croydon during the afternoon of the 10th.\* On the 11th, the Atlantic anticyclone had extended across the British Isles and the 11th and 12th were both cold sunny days, 8·7 hrs. of bright sunshine were experienced at Holyhead on the 11th and 9·0 hrs. at Ross-on-Wye on the 12th. From the 13th to 23rd pressure remained high from Iceland to the Azores and low to the east of the British Isles, and the weather was mainly cold and sunny. From the 13th to 17th there were only light showers of rain and a slight sprinkling of snow locally over the whole country but from the 17th to 23rd snow fell to a considerable depth in the north and east and light snow showers occurred in the south even as far as Guernsey. Sunshine records were good over the country generally during this period and especially on the 22nd and 23rd when over 9 hrs. bright sunshine were recorded at several places. On the evening of the 23rd a depression formed over north Ireland and moved later to a position off south Ireland, deepening considerably. Snowstorms occurred over the greater part of the British Isles and were especially severe in Wales, the Midlands and northern England† and strong south-easterly winds increasing to gale force at times were experienced in the Midlands and south. By the 26th southerly winds had brought milder weather and the rainfall on that day combined with the melting snow caused floods in many parts of southern England. The 27th and 28th were also mild days with occasional rain, heavy locally, but bright intervals. At Fofanny (Co. Down), 3·10 in. fell on the 28th. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	58	0	Liverpool	80	+21
Aberdeen	70	— 3	Ross-on-Wye	86	+24
Dublin	74	+ 1	Falmouth	80	+ 3
Birr Castle	66	— 1	Gorleston	77	— 4
Valentia	88	+17	Kew	76	+16

The special message from Brazil states that the rainfall in the northern and southern regions was irregular in distribution with averages 0·28 in. above normal and 0·31 in. below normal

\* See p. 35.

† See p. 29.

respectively, but in the central regions very scarce with average 1.71 in. below normal. Four anticyclones passed across the country and a continental depression developed in the south. The crops were generally in good condition. At Rio de Janeiro pressure was 0.2mb. above normal and temperature normal.

*Miscellaneous notes on weather abroad culled from various sources.* Following the thaw at the end of January ten days of spring weather prevailed in Switzerland during which the snow melted rapidly up to the 5,000-ft. level. By the 13th however, wintry weather had returned. Snow fell heavily about the 18th and skiing conditions were generally excellent during the rest of the month. Near Avila, Spain, several trains were detained by heavy snowfalls about the 20th, there being 5 ft. of snow in the station of La Cañada, near the tunnel through the Sierra Guadarrama. Gales were experienced in Sicily about the 23rd. Snow fell to a depth of half an inch at Cannes in the early morning of the 24th but quickly disappeared in the bright sunshine during the day. (*The Times*, January 31st-February 25th.)

It was unusually cold over Morocco round about the 22nd and motor cars were blocked by snow on one of the Atlas passes. (*The Times*, February 23rd.)

A heat wave passed over Brisbane early in the month, but about the 16th the overdue rains had spread there as well as to other parts of Queensland. (*The Times*, February 15th-16th.)

Communication was re-established about the 12th with Sandy Point, the fishing village on the west coast of Newfoundland, which had been cut off by a gale and high tides during the previous week. Temperature was above normal in the eastern part of North America during the first days of the month but the intense cold spell experienced in the west soon spread also to the east. During the week ending the 14th mean temperature was as much as 29°F. below normal at Yellowstone Park (Wyoming) and Grand Junction (Colorado) while -46°F. was registered at White River, Ontario, on the 9th. Severe snowstorms also accompanied the cold spells, many trains being snowbound and telegraph wires broken. During the following two weeks temperature rose considerably above the normal especially in the west. Precipitation was generally below normal in the western United States and variable in the eastern States. (*The Times*, February 10th-13th, and *Washington, D.C., U.S. Dept. Agric. Daily Weather Map and Weekly Weather and Crop Bulletin*.)

### General Rainfall for February, 1933

England and Wales	...	100	} per cent of the average 1881-1915.
Scotland	...	123	
Ireland	...	109	
British Isles	...	<u>140</u>	



## Rainfall: February, 1933: England and Wales.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>London</i>	Camden Square .....	1.46	87	<i>Leics.</i>	Thornton Reservoir ...	2.05	177
<i>Kent</i>	Tenterden, Ashenden ...	1.09	101	"	Belvoir Castle .....	3.11	188
"	Folkestone, Boro. San. ...	1.04	...	<i>Kut.</i>	Ridlington .....	2.85	174
"	St. Peter's, Maidensham ...	...	...	<i>Lines</i>	Boston, Skirbeck .....	1.61	112
"	Eden'ldg., Falconhurst ...	2.68	121	"	Granwell Aerodrome ...	1.72	115
"	Sevenoaks, Speldhurst ...	...	...	"	Skewness, Marine Gdns ...	1.03	67
<i>Sus.</i>	Compton, Compton Ho. ...	4.58	173	"	Louth, Westgate .....	2.30	124
"	Patching Farm .....	2.13	90	"	Brigg, Wrayby St. ...	2.35	...
"	Eastbourne, Wil. Sq. ...	1.92	80	<i>Notts.</i>	Workop, Hodsack ...	3.25	211
"	Heathfield, Burkye ...	2.88	122	<i>Derby.</i>	Derby, L. M. & S. Rly. ...	2.91	180
<i>Hants.</i>	Ventnor, Roy. Nat. Hos. ...	3.56	100	"	Buxton, Terr. Slopes ...	4.66	124
"	Fordingbridge, Oaklands ...	4.40	170	<i>Ches.</i>	Runcorn, Weston Pt. ...	3.20	177
"	Ovington Rectory .....	0.48	240	<i>Lancs.</i>	Manchester, Whit Pk. ...	3.07	160
"	Sherborne St. John ...	4.44	202	"	Stonyhurst College ...	4.82	141
<i>Herts.</i>	Welwyn Garden City ...	1.84	...	"	Southport, Husketh Pk ...	2.88	137
<i>Hucks.</i>	Slough, Upton .....	3.21	180	"	Lancaster, Greg. Ohay. ...	4.08	141
"	H. Wycombe, Mackwell ...	2.01	...	<i>Yorks.</i>	Wath-upon-Deane ...	3.43	200
<i>Oxf.</i>	Oxford, Mag. College ...	2.02	185	"	Wakefield, Clarence Pk. ...	4.30	251
<i>Nor.</i>	Pitsoford, Selghrook ...	2.77	106	"	Oughtershaw Hall .....	7.03	...
"	Omble .....	1.57	...	"	Wetherby, Ribston H. ...	5.24	303
<i>Heds.</i>	Woburn, Crawley Mill ...	1.01	109	"	Hull, Pearson Park ...	3.08	185
<i>Cam.</i>	Cambridge, Bot. Gdns. ...	...	...	"	Holme-on-Spalding ...	4.14	...
<i>Hessa.</i>	Chelmsford, County Lab ...	1.14	77	"	West Witton, Ivy Ho. ...	5.40	180
"	Lexden Hill House ...	.05	...	"	Felixkirk, Mt. St. John ...	5.60	334
<i>Staff.</i>	Haughley House .....	1.37	...	"	York, Museum Gdns. ...	4.11	272
"	Campden Ash .....	1.07	121	"	Pickering, Ilungate ...	4.12	237
"	Lowestoft Sec. School ...	...	...	"	Searborough .....	3.31	197
<i>Norf.</i>	Bury St. Ed. Westley H. ...	1.88	125	"	Middlesbrough .....	3.04	234
<i>Wills.</i>	Wells, Holkham Hall ...	1.91	120	"	Balderdale, Hury Res. ...	...	...
"	Dovizes, Highclere ...	3.75	189	<i>Durh.</i>	Ushaw College .....	4.09	205
<i>Dor.</i>	Cahoe, Castlesway .....	3.15	154	<i>Nor.</i>	Newcastle, Town Moor ...	3.20	202
"	Evershot, Melbury Ho. ...	5.02	100	"	Boltonham, Highgreen ...	4.07	180
"	Weymouth, Westman ...	4.01	185	"	Lilburn Tower Gdns. ...	3.05	108
"	Shaftesbury, Abbey Ho ...	3.88	108	<i>Cumb.</i>	Carlisle, Sealeby Hill ...	2.56	115
<i>Devon.</i>	Plymouth, The Hoe ...	3.77	127	"	Borrowdale, Southwaite ...	...	...
"	Holme, Church Pk. Cott. ...	0.80	124	"	Borrowdale, Moraine ...	13.47	...
"	Telgmouth, Den Gdns. ...	4.30	105	"	Keswick, High Hill ...	5.85	108
"	Onlampton .....	4.45	159	<i>West.</i>	Appleby, Castle Bank ...	2.61	85
"	Sidmouth, Sidmouth ...	4.32	173	<i>Mon.</i>	Abergavenny, Tareh ...	5.31	166
"	Barnstaple, N. Dev. Ath ...	3.50	120	<i>Glouc.</i>	Yatalyston, Worn Ho. ...	0.05	135
"	Dartm'r, Cranmore Pool ...	5.00	...	"	Cardiff, Ely P. Sta. ...	5.04	108
"	Okhampton, Uplands ...	0.02	138	"	Treherbert, Tynywam ...	10.67	...
<i>Corn.</i>	Redruth, Trowleg ...	4.05	107	<i>Carm.</i>	Carmarthen Friary ...	3.04	106
"	Penzance, Morrah Gdn. ...	3.50	107	<i>Pemb.</i>	Inverfordwest, School ...	3.70	100
"	St. Austell, Trevarna ...	4.31	112	<i>Card.</i>	Aberystwyth .....	3.42	...
<i>Soms.</i>	Chowton Mondip .....	3.00	118	<i>Rail.</i>	Blwm W. W. Tynywedd ...	0.51	124
"	Long Ashton .....	3.03	107	<i>Mont.</i>	Lake Vyrnwy .....	8.27	182
"	Street, Millfield .....	...	...	<i>Flint.</i>	Sealand Aerodrome ...	2.32	140
<i>Glos.</i>	Blockley .....	8.35	...	<i>Mer.</i>	Dolgelly, Bontddu ...	5.04	193
"	Cirencester, Gwynfa ...	3.88	100	<i>Carm.</i>	Llandudno .....	2.83	180
<i>Here.</i>	Ross, Brethlen .....	3.80	193	"	Snowdon, L. Llydaw ...	10.06	...
"	Ladbury, Underdown ...	8.04	107	<i>Ang.</i>	Holyhead, Salt Island ...	2.05	84
<i>Salop.</i>	Church Stretton .....	3.00	181	"	Tilgwy .....	2.40	...
"	Shifnal, Hatton Grange ...	3.35	207	<i>Isle of Man</i>	...	...	...
<i>Staff's.</i>	Market Drayton, Old Sp. ...	2.50	145	"	Douglas, Boro' Com. ...	4.24	130
<i>Worc.</i>	Ombersley, Holt Lock ...	2.01	177	<i>Guernsey</i>	...	...	...
<i>War.</i>	Birmingham, Edgbaston ...	3.30	230	"	St. Peter's, Hatton Grange Rd ...	3.72	151

*Erratum:* St. Peter's, Maidensham, January, for '60 | 32 read 2.17 | 125.

## Rainfall: February, 1933: Scotland and Ireland.

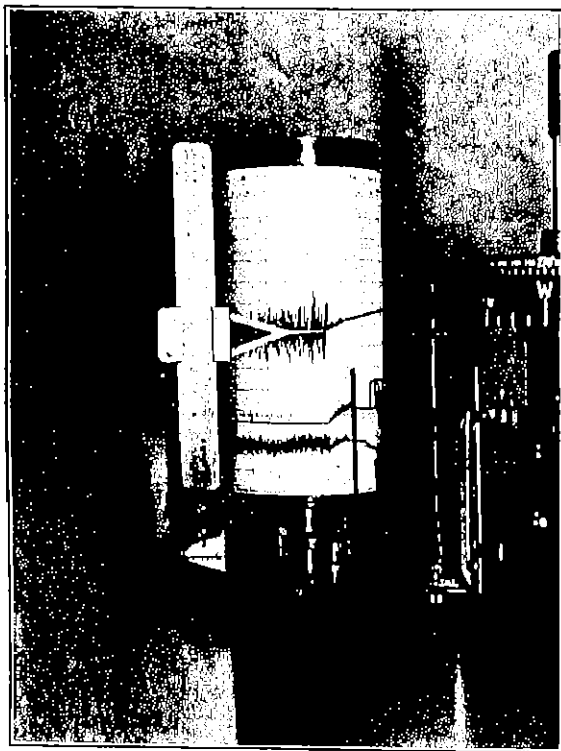
Co.	STATION	In.	Per- cent of Av.	Co.	STATION	In.	Per- cent of Av.
<i>Wigt.</i>	Pt. William, Monroith	3.00	120	<i>Suth.</i>	Melville	4.79	100
	New Luce School	...	...		Loch More, Achfary	7.58	115
<i>Kirk.</i>	Dalry, Glendarroch	5.75	118	<i>Caith.</i>	Wick	3.40	152
	Carsphairn, Shiell	7.72	117	<i>Ork.</i>	Pomona, Deerness	3.08	132
<i>Dumf.</i>	Dumfries, Orlerton, R.I.	2.54	82	<i>Shet.</i>	Lerwick	3.52	111
	Baskalennuir Obs.	7.00	141	<i>Cork.</i>	Calderagh Rectory	2.59	...
<i>Roar.</i>	Bransholm	3.27	124		Dunmanway Rectory	2.05	55
<i>Sell.</i>	Ettrick Mause	4.06	88		Cork, University Coll.	2.25	60
<i>Peab.</i>	West Linton	3.31	...		Ballinacura	2.48	66
<i>Berw.</i>	Marchmont House	2.90	139	<i>Kerry.</i>	Valentin Obys	2.00	40
<i>E. Lot.</i>	North Berwick Res.	1.03	104		Garrahacon	6.40	...
<i>Midl.</i>	Edinburgh, Roy. Obs.	1.15	69		Killarnoy Asylum	...	...
<i>Lun.</i>	Auchlyfardo	3.55	...		Darrynane Abbey	2.90	65
<i>Ayr.</i>	Kilmaronock, Kay Pk.	...	...	<i>Wat.</i>	Waterford, Gortnoro	3.83	110
	Girvan, Plunmore	3.26	76	<i>Tip.</i>	Neenagh, Cas. Longh	3.52	113
<i>Renf.</i>	Glasgow, Queen's Pk.	2.73	93		Rosera, Timoney Park	2.12	...
	Greenock, Prospect H.	4.38	87		Cashel, Ballinamona	3.43	107
<i>Bute.</i>	Rothessay, Ardenaraig	4.87	...	<i>Lin.</i>	Faynes, Coolmaes	3.77	150
	Douglas Lodge	6.53	...		Castlecounel Rec.	4.17	...
<i>Arg.</i>	Ardgour House	8.31	...	<i>Claro.</i>	Inagh, Mount Callan	3.00	...
	Glen Etive	...	...		Broadford, Hurdlest'n	3.05	...
	Oban	5.53	126	<i>Wexf.</i>	Gorey, Courtown Ho.	5.00	131
	Pollaloch	5.33	127	<i>Kilk.</i>	Kilkenny Castle	3.65	144
	Inveraray Castle	7.08	117	<i>Wick.</i>	Rathnew, Clonmannon	5.92	...
	Islay, Ballabus	6.14	146	<i>Carl.</i>	Hacketstown Rectory	3.92	181
	Mull, Benmore	...	...	<i>Lanc.</i>	Blundestown House	4.15	155
	Tiree	3.56	103		Mountmellick	5.26	...
<i>Kinr.</i>	Loch Loven Sluice	2.90	102	<i>Offaly.</i>	Birr Castle	2.32	101
<i>Perth.</i>	Loch Dhu	6.65	89	<i>Kild'r.</i>	Monasteravin	...	...
	Balquhadder, Stronvar	4.07	...	<i>Dublin.</i>	Dublin, FitzWm. Sq.	3.40	180
	Orkell, Strathearn Hyd.	3.52	100		Ballbriggan, Ardghillan	2.52	129
	Blair Castle Gardens	4.31	154	<i>Meath.</i>	Boampara, St. Cloud	3.60	...
<i>Angus.</i>	Kettins School	3.00	176		Kells, Headfort	3.68	130
	Pearcie House	4.00	...	<i>W. M.</i>	Moate, Coolatara	3.05	...
	Montrose, Sunnyside	2.06	112		Mullingar, Belvedere	3.34	120
<i>Aber.</i>	Braemar, Bank	3.34	117	<i>Long.</i>	Castle Forbes Gdns.	3.30	116
	Lagle Coldstone Sch.	3.25	156	<i>Gal.</i>	Ballynahinch Castle	3.60	70
	Aberdeen, King's Coll.	3.71	130		Galway, Grammar Sch.	1.52	...
	Fyvie Castle	5.30	236	<i>Mayo.</i>	Mallacrumy	4.65	...
<i>Moray.</i>	Gordon Castle	3.48	181		Westport House	3.45	87
	Grantown-on-Spey	3.02	142		Delphi Lodge	5.65	67
<i>Nairn.</i>	Nairn	1.99	111	<i>Sligo.</i>	Markree Obys	3.14	92
<i>Inver.</i>	Ben Alder Lodge	4.84	...	<i>Cavan.</i>	Belturbet, Claverhill	1.79	107
	Kingussie, Tho Breches	2.67	...	<i>Ferm.</i>	Enniskillen, Portora	...	...
	Loch Quoich, Loan	13.10	...	<i>Arm.</i>	Armagh Obys	2.88	129
	Glenquoich	9.00	87	<i>Down.</i>	Fofunmy Reservoir	5.93	...
	Inverness, Ouldthel R.	2.04	...		Seaford	3.22	100
	Arisaig, Fairs-na-Sguir	4.75	...		Donaghadee, C. Stu.	3.54	153
	Fort William, Glasdrum	...	...		Banbridge, Milltown	2.82	136
	Skye, Dunvegan	4.08	...	<i>Antr.</i>	Belfast, Cavohill Rd.	3.55	...
	Barr, Skallary	3.32	...		Aldergrove Aerodrome	3.04	130
<i>R. &amp; C.</i>	Alness, Ardross Castle	3.51	100		Ballymona, Harryville	3.54	109
	Ullapool	5.01	117	<i>Lon.</i>	Londonderry, Creggan	3.10	99
	Achnashellach	7.71	100	<i>Tyr.</i>	Omagh, Edensol	3.37	113
	Stornoway	3.43	77	<i>Don.</i>	Malla Head	3.96	...
<i>Suth.</i>	Lairg	4.73	152		Milford, The Mause	2.08	82
	Tongue	5.58	160		Killybegs, Rockmount	3.89	68

## Climatological Table for the British Empire, September, 1932

STATIONS	Mean of Day M.S.L.	Diff. from Normal	Absolute			Mean Values			Mean	Rel. Humidity	Mean Cloud Amt	Amt	Diff. from Normal	Days	Hours per day	Per-cent- age of possible
			Max.	Min.	° F.	Max.	Min.	1/2 and 3/4 min.								
	mb.	mb.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	%	0-10	in.	in.			
London, Kew Obsy.	1018.2	-4.2	75	42	84.6	51.1	57.9	+0.8	52.9	91	6.6	2.32	+0.45	15	3.4	27
Gibraltar	1015.9	-1.4	89	54	79.6	64.6	72.2	-0.3	63.8	88	4.3	1.30	+0.09	6	9.7	78
Malta	1016.7	+0.4	91	66	83.8	71.3	77.5	+1.5	71.7	79	3.3	1.17	-0.10	4		
St. Helena	1017.4	+0.8	60	51	57.2	52.5	54.9	-2.5	53.5	96	9.9	3.59		24		
Freetown, Sierra Leone	1015.2	+3.0	87	71	82.4	72.6	77.5	-1.6	74.5	89	8.3	23.84	-4.64	28		
Lagos, Nigeria	1013.6	+1.4	85	71	81.6	73.6	77.6	-1.1	73.4	86	9.6	4.11	+1.48	11	9.6	30
Kaduna, Nigeria	1013.9	-0.4	89		83.5				70.9	88	8.7	13.83	+2.33	20	5.0	41
Zomba, Nyasaland	1011.1	-2.6	89	52	83.6	60.4	72.0	+2.5		54	2.6	0.00	+0.34	0		
Salisbury, Rhodesia	1013.3	-1.4	89	44	81.1	56.3	68.7	+2.3	55.8	41	1.4	0.85	+0.07	1	8.7	73
Cape Town	1019.3	0.0	77	45	64.3	50.7	57.7	-0.2	52.4	84	6.3	2.23	-0.01	12		
Johannesburg	1013.7	-1.0	80	38	73.9	50.9	62.4	+3.0	47.6	34	2.7	0.80	-0.16	5	9.6	81
Mauritius	1020.9	+0.7	79	60	76.5	64.4	70.4	+1.0	64.0	73	6.3	2.31	+1.01	24	7.5	63
Calcutta, Alipore Obsy.	1002.7	-1.8	92	75	89.2	79.2	84.2	+1.0	79.9	91	7.3	10.38	+0.32	18*		
Bombay	1006.2	-1.8	92	73	87.5	77.2	82.3	+1.4	77.3	86	6.4	11.13	+0.45	11*		
Madras	1005.8	-0.7	97	72	92.7	77.4	85.1	-0.1	75.8	72	5.8	4.45	+0.40	5*		
Colombo, Ceylon	1010.4	+0.5	87	73	84.8	76.6	80.7	-0.5	77.1	79	7.2	7.16	+2.10	20	6.3	52
Singapore	1009.3	-0.5	91	70	86.8	74.4	80.6	-0.5	77.1	80	7.1	9.74	+2.35	16	5.6	46
Hongkong	1008.2	-0.1	88	75	83.9	77.1	80.5	-0.5	75.6	79	7.9	4.34	+5.33	12	4.5	36
Sandakan									77.1	81	7.0					
Sydney, N.S.W.	1018.4	+2.3	79	44	65.0	51.6	58.3	-0.9	55.2	77	7.8	7.95	+5.09	23	5.6	47
Melbourne	1019.7	+3.9	73	39	63.3	46.0	54.7	+0.6	50.6	75	7.1	0.81	+1.63	13	5.0	43
Adelaide	1018.9	+1.4	78	42	67.1	48.8	57.9	+0.8	53.3	64	6.0	2.01	-0.04	14	6.5	55
Perth, W. Australia	1019.2	+1.2	82	39	67.8	49.6	58.7	+0.5	53.2	66	3.7	1.58	-1.54	10	8.3	70
Coorgardie	1018.4	+1.3	85	31	71.4	45.2	58.3	-0.4	50.3	62	2.1	0.35	+0.32	2		
Brisbane	1016.3	-0.8	82	47	73.7	54.4	64.1	-1.1	58.3	69	4.2	3.00	+0.95	12	7.9	66
Hobart, Tasmania	1018.8	+7.8	66	36	58.2	44.5	51.3	+0.3	46.9	69	6.1	1.63	+0.44	11	5.4	46
Wellington, N.Z.	1023.2	+8.6	65	38	58.5	43.9	48.7	-2.9	46.6	79	8.2	1.05	-2.92	15	4.4	37
Suva, Fiji	1013.7	-0.6	90	65	82.4	73.0	76.7	+2.2	72.4	74	6.5	3.39	+1.30	17	5.6	47
Apia, Samoa	1011.3	-0.9	88	70	84.7	73.1	78.9	+0.7	76.1	79	4.7	6.27	+1.16	9	7.7	64
Kingston, Jamaica	1011.3	-0.9	94	72	90.2	73.5	81.9	+0.4	73.4	81	2.9	1.01	+3.02	8	8.6	70
Grenada, W.I.																
Toronto	1018.2	+0.4	87	38	70.7	53.4	62.1	+1.8	55.5	81	2.9	3.04	+0.37	10	8.1	65
Winnipeg	1016.0	+2.2	86	30	68.2	43.9	56.1	+2.4	43.8	81	4.1	1.89	+0.33	7		
St. John, N.B.	1017.0	-0.4	78	38	68.1	50.9	58.5	+2.6	54.4	82	6.3	3.21	+0.53	16	5.6	44
Victoria, B.C.	1020.2	+3.8	76	44	65.8	49.4	57.6	+1.5	54.0	81	3.5	0.56	+1.25	5	8.6	68

\* For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen.





DINES ANEMOGRAPH WITH ACCESSORIES (see p. 69)

# The Meteorological Magazine



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## Summer Thunderstorms

By C. K. M. DOUGLAS, B.A.

1. *General Thermal Structure.*—It is convenient for practical purposes to distinguish the layers below and above the condensation level. In the lower region the lapse-rate of temperature, the horizontal temperature gradient, orographic features on the ground, converging winds; and probably the dynamical effects of wind shearing (i.e., variation with height), are all important factors. In some cases when the relative humidity is high, only a small vortical displacement is required to form clouds. Above the cloud base the saturated adiabatic lapse-rate proves to be a sound criterion of stability. Only a small excess over this value is required, but as a rule the clouds must be able to grow to a height exceeding 10,000 feet from base to summit before thunderstorms develop, and although on some occasions the height is less, it is usually much greater. The large number of tephigrams now available show that nearly all the energy is released above the condensation level, so that the rising air must gain vortical velocity far up into the clouds, except in so far as it is retarded by friction with the surrounding air, or with solid or liquid particles. A quantitative use of the energy, measured by tephigrams proves difficult, partly owing to the lack of an absolute criterion of the intensity of a storm. The severity noted at a particular place must depend partly on whether the storm happens to be overhead or a few miles away.

(1307) 107/27-1,050-4/33 M. & S. Gp. 303.

So far there seems to be a complete lack of upper air observations within the storms. Observations made just outside thunderstorms, plotted on tephigrams or Hertz diagrams, show that air rising adiabatically would often be  $5^{\circ}\text{F}$ . or more warmer than its environment (in extreme cases over  $10^{\circ}\text{F}$ .), through a considerable range of height, probably sometimes up to the tropopause. If we consider a column of air in hydrostatic equilibrium extending from the ground to 8 kilometres, and there is no pressure change at the top, then a rise of  $1^{\circ}\text{F}$ . of the mean temperature of the column involves a fall of pressure of over 2 mb. at the ground. Actually there is usually a rise of pressure under a thunderstorm, once the precipitation has started. Occasionally the barograph drops sharply just outside the rain area, but rarely falls more than 1 mb. below its undisturbed level. Little is known about the vertical acceleration, but its effect must be small. If there is a vertical acceleration of 2 cm. per sec. per sec. up to 5 kilometres (giving a vertical velocity of 14 metres per second at that height), and if its cumulative effect is all transmitted downwards, and friction is neglected, there would be a rise of surface pressure of 1 mb. to be superposed on the statical effect. This figure may be exceeded for short periods over small areas, especially in view of the importance of friction, but when averaged over a period of hours, and over the whole area of the storm, the effect in question must be less. Thus the available evidence seems to show that the storm is little warmer than its environment. Factors tending to reduce the temperature in the storm are mixing with the environment, and the effect of precipitation, especially hail, soft hail and snow melting into rain. Near the ground the cooling is increased by evaporation, and the importance of the resulting pool of cold air is generally recognised.

It should be kept in mind that thunderstorms normally take hours to develop, and that a severe storm generally covers a considerable area. The scale of the phenomena is important: small scale convection cannot in itself cause a thunderstorm.

2. *Diurnal Variation*.—In hot weather in south-east England there are more thunderstorms in the evening and night than there are before 18h. G.M.T. I have examined the data in the *Daily Weather Report* for the period 1916-32 in the forecast districts, south-east England, east England and east Midlands, and noted cases of thunder with a day temperature reaching  $75^{\circ}\text{F}$ . or more, either at the same place or within 60 miles, and find that there were 62 cases during the period 7h. to 18h., and 85 cases during the period 18h. to 7h. following the warm days. Many of the late evening and night storms were previously-formed diurnal convectional storms, but many others were of a different type, though no doubt due partly to the surface heating and convection during the day, especially to heating on the

continent when there was an upper current exceeding 20 m.p.h. from a southerly point. (Each day or night was only counted once.)

Thunderstorms on hot afternoons are never numerous, and in late summer they are extremely rare. Out of 173 days when the temperature reached 80°F. somewhere in the London area during the period 1916-32, thunder occurred in the area between 7h. and 18h. only on nine days, or 5 per cent, and the percentage is even smaller if one considers one place only. (A report of thunder at any London station in the *Daily Weather Report*, including Croydon, determined a day of thunder; temperatures of 80°F. or more at any station except Greenwich or Camden Square were included.) In the middle of London the only severe storm of diurnal convection type on a day when temperature reached 80° was on June 16th, 1917. The severe storm of July 10th, 1923, just skirted the south-west suburbs; the storms of June 18th, 1917, and of July 22nd, 1925, were of an entirely different type, and the other storms on the list were not severe. Storms in the afternoon generally require cumulus formation to commence before noon, but in hot weather the temperature is high at the height of a few thousand feet, and the relative humidity near the ground is usually low, so that cumulus formation is usually delayed and may never commence at all. Quite a number of afternoon storms develop in definitely cool weather in polar air, associated with a large deficiency of upper air temperature. More often the surface temperature is near the normal, and the lapse-rate is slightly above normal through a large range of height. The necessary conditions as regards humidity and lapse-rate are usually associated with a depression, a trough, or a col of a shape which gives convergence (see Section 4 below). A favourite region is the centre of an old Atlantic depression which has drifted over land, even if it has largely filled up, and perhaps degenerated into a rounded trough of low pressure. The air has generally followed an irregular track, with mainly cyclonic curvature, between latitudes 47° and 60°. It is often called "maritime sub-polar air" but labels of this type are not very helpful. A suitable length of land track is required for storms of diurnal convection type, varying according to the strength of the upper wind, and at coast stations it is important that the upper wind should have a component off land. For the development of local thunderstorms there should not be too much vector change of wind with height, at least above the cloud base, as otherwise the top of the rising column is sheared away and the clouds break up.

Night storms are of two main types, which we may term low-based and high-based. The former are mainly winter, maritime or coastal, and polar air phenomena, and they are rare in early summer. The latter are essentially associated with warm weather, because an adequate moisture supply at 4,000 feet or above



requires a high temperature at those levels, and the surface layers are quickly warmed up unless there is a thick low cloud sheet from the North Sea. The height of the base of the storm ranges up to probably 10,000 feet in extreme cases (in lower latitudes this figure is exceeded). High level storms may occur during the day, but they are probably more frequent at night.

At stations where there is a complete record of thunder throughout the 24 hours for several years, it would be worth while to examine the diurnal variation in relation to temperature and other factors.

**3. Upper Wind Structure.**—Many thunderstorms are associated with warm south-east winds from the continent, and since the west component of wind velocity increases with height on the average, there is often a south-west current higher up. Sometimes the development of thunderstorms is helped by a slight fall of upper air temperature, especially above 10,000 feet. The combination of these two facts has sometimes given rise to the misleading notion that thermal instability is developed between a warm south-east current and an over-running colder south-west current, even at considerable heights. Such a process is *a priori* improbable, because when the geostrophic wind veers with increasing height, the effect of the horizontal motion is to increase the temperature. (This was first pointed out by Exner, and I mentioned it in 1922,\* adding that a veer above 10,000 feet was unfavourable for thunder. The results given below show that this is true even above 5,000 feet.

Since single summerns are apt to be misleading, I have examined the whole period from 1923 to 1932, from May to September, in the south-eastern area (south-east and east England and east Midlands). Pilot balloon observations were used up to 5,000 feet, and when available to 15,000 feet, but these were rare, and the high level current usually had to be determined from nephoscope observations. Alto-cumulus observations were preferred when available (since the middle levels are the important ones for thunderstorms), but in many cases cirrus observations were used. The great majority of high level south-easterly currents extended right up to the cirrus. Due south winds, or cases of a roughly equal number of observations with east and west components, were ignored. The occurrence of thunder anywhere in the area, within 12 hours after the wind observation, was determined from the *Daily Weather Report*, with the condition that the thunder should be within 100 miles of the place of measurement of the upper wind. Only two observations per day were used, normally morning and evening.

The results showed that out of 156 cases of winds at 5,000 feet in the south-east quadrant, there were 121 cases with

\* London, *Q.J.R. Meteor. Soc.*, 48, 1922, p. 355. The subject is discussed quantitatively in *Mem. R. Meteor. Soc.* 1, 1920, No. 7. A fair measure of agreement was found between fact and theory.

a wind in the south-west quadrant at the higher levels, and thunder occurred within 12 hours in 34 cases, or 28 per cent. There were 35 cases when the south-east current extended right up to the higher levels (middle or upper troposphere, usually both), and thunder occurred within 12 hours in 23 cases, or 66 per cent. It is satisfactory to find theory confirmed in this manner.

The layers from 1,000 to 5,000 feet, and thence up to the higher levels, were then examined separately. Out of 170 cases of south-east wind at 1,000 feet, there were 57 with south-west winds at 5,000 feet, and thunder followed in 18 cases, or 32 per cent. There were 113 cases of south-east wind up to 5,000 feet, and thunder followed in 41 of these, or 36 per cent. The difference is small and probably has no significance. In some cases with thunder in the last group, there was a considerable veer up to 5,000 feet, though the wind remained east of south. Sometimes it certainly appears as if the advection of warm air in the lower levels, associated with a wind veering upwards, increases the lapse-rate at the top of the layer affected, and helps the development of thunderstorms. At Borek (north-east France) in 1918, aeroplane observations were made on three occasions very close to thunderstorms of this type on summer evenings, with clouds at 5,000 or 6,000 feet moving from south-south-west, and south-easterly winds lower down. The lapse-rate from 1,000 feet up to the cloud level was above the normal, and it is fairly certain that advection had increased it, even though equally high values were sometimes observed in fine hot weather or in polar air. The lapse-rate in the south-south-west upper current was also above normal. The lapse-rate below the clouds was nearly up to the dry adiabatic, but nowhere quite reached that figure. The thunderstorms occurred along cold fronts, and no isolated storms were visible; so that the breakdown of stability was due to the trigger action of the front, and did not take place spontaneously. Subsequent experience has shown that storms of this type are almost always associated with fronts, whereas super-adiabatic lapse-rates have not yet been observed.

Turning now to the upper layers, we find that out of 107 cases of south-east wind at 5,000 feet, there was an upper south-west current in 66 cases, and thunder followed within 12 hours in 19 cases, or 29 per cent; while the south-east current extended to medium or high levels in 41 cases, with thunder after 30 of these, or 73 per cent. (The examples in this group are not quite identical with those discussed earlier, as there were some cases when the wind was north-easterly at 1,000 feet, but south-easterly higher up.) The results at these levels are decisive.

Fairly frequently there is a slight or moderate fall of temperature at high levels before the thunderstorms, generally accompanied by a fall of the barometer and a transition from an anti-

cyclone to a shallow depression. The upper wind direction is not in itself important, so long as it does not veer with height. As a rule the direction does not change much with height, though there is often an increase of velocity. In the case of a slow fall of temperature it is not necessary that the wind should back with height, even when the fall is due to advection, which is by no means the only factor. If there is anything in the nature of a travelling rotary system, there is a small wind component across the isobars bringing over the colder air.\*

It is almost certain that the fall of temperature at high levels is not directly connected with land and sea distribution. A change from a warm anticyclone to a relatively cold depression may take place at any season. It may also be noted that similar synoptic situations give thunderstorms in the eastern United States, and also sometimes near our western coasts, even when no continental air can have reached that region. The storms are less frequent in the west than in the south-east, but it must be remembered that a suitable lapse-rate in the middle layers of the troposphere is only one of the factors required for thunderstorms.

Sometimes there are widespread outbreaks of thunderstorms moving from south or south-west over the British Isles, while near the ground there is an easterly current which is warm in the south of England but cool further north, chiefly owing to the North Sea. A feature common to the whole area is marked wind shearing below the level of the cumulo-nimbus clouds, which may produce dynamical effects helping to start off thunderstorms. Above the cloud base, shearing is rarely large, but there is no reason to believe that moderate shearing destroys widespread, as distinct from purely local, thunderstorms. Any marked wind discontinuity generally indicates a thermally stable layer, and any thunderstorms which develop must be entirely above or below it. A discontinuity at about 8,000 to 10,000 feet is on the average the most effective for stopping thunderstorms.

4. *The Moisture Supply.*—Most of our severe storms occur when the dew-point is higher than the sea temperature near our coasts, so that no evaporation can take place there. The sea south of latitude  $49^{\circ}$  is no doubt usually the ultimate source of the moisture, but frequently the air has been over the land for a considerable period. Evaporation from the land adds moisture, especially if the ground is wet, but convective mixing carries up moisture out of the surface layer, more particularly if the humidity is low in the upper air. When air passes from sea to land, the absolute humidity may increase, decrease, or remain constant, according to the relative magnitude of these factors. If there is no precipitation, the total moisture in a column of air

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\* London. Mem. R. Meteor. Soc. 1, 1926, No. 7, p. 101, and London Q.J.R. Meteor. Soc., 55, 1929, p. 145.

will normally increase over land, as evaporation can never be zero in Europe in summer, and this moisture may later become available for thunderstorms, especially if convection is at first limited to the lowest 6,000 feet.

Increases of moisture which are attributed to the replacement of continental by maritime air may be really due to the replacement of an anticyclone by a depression, which usually comes in from west. If there is a depression over eastern France and an anticyclone off the Bay of Biscay, the chances of thunder spreading to England are enormously greater with a south-easterly than with a south-westerly upper current. The immenso influence of the pressure distribution on the humidity is of course due to convergence or divergence, which is a dominant factor, even if we ignore development and consider only the effect of surface friction. Dr. F. J. W. Whipple\* has shown that the total

flow at right angles to an isobar is  $\frac{G \sin \alpha \cos \alpha}{B}$  where  $G$  is the gradient wind, and  $\alpha$  the angle between the isobars and the surface wind, and  $B^2 K = \omega \sin \lambda$ , where  $K$  is the coefficient of eddy diffusivity. If we take  $K = 10^5 \text{ cm}^2 \text{ per sec.}$ , then a volume of 1,300 cubic metres of air flows over each metre of isobar per second. This is a high value of  $K$ , but it is reasonable on a summer day. With a surface temperature inversion,  $K$  is usually below  $10^4$ , so that the flow across the isobars is less, in spite of a larger value of  $\alpha$ . The order of magnitude of the flow can be verified from pilot balloons, but the variation is large, and in thundery weather small irregularities make accurate computation impossible. If we take a circle of radius of 500 Km., and a flow of 1,300 cubic metres per metre per second, with a water content of 12 gms. per cubic metre (corresponding to a relative humidity of 50 per cent. at a temperature of  $77^\circ\text{F.}$ ), then the inflow in 12 hours would carry in moisture equivalent to a layer of water 3 mm. deep over the area. This moisture could add 25 per cent to the relative humidity of a layer a kilometre thick at a mean temperature of  $50^\circ\text{F.}$  At night, or over the sea in summer, the inflow would be less, owing to the smaller value of  $K$ . The increase of moisture per unit area would be larger with a smaller circle, and less with a weaker gradient. In the case of many depressions and most anticyclones, the same air mass remains for a few days in the same system, so that the effect of convergence or divergence is cumulative, and must be much greater than land and sea effects.

It is interesting to note that whether we consider lapse-rate or humidity, the most important factor proves to be the pressure distribution, which is the historic basis of forecasting. The isobaric systems and their movements and developments, as shown especially by the barometric tendencies, are still the central foundation of forecasting, and will probably always remain so,

\* London, *Q.J.R. Meteor. Soc.*, 46, 1920, p. 45, (equation 6.4).

however valuable supplementary information may be in certain cases.

Sometimes thunderstorms develop when the air is dry above 5,000 feet or so, except in the cumulus clouds. It should be kept in mind when interpreting observations on a tephigram or Hertz diagram that a particular humidity reading may depend on whether it was taken inside or outside a cloud. In the case of widespread storms the air is usually damp through a large range of height, but even then there may be damp and dry zones near together.

5. *Relation with Fronts.*—Though fronts are obviously of great importance in connexion with thunderstorms, the exact relation is very variable, and the problem is complicated by local squalls due to heavy rain or hail. Quite a number of cold fronts after hot weather, even in the afternoon, pass without thunder. A considerable number of storms are associated with warm or stationary fronts, though these may not be sharply defined. Whatever be the nature of the front, it frequently happens that the storms are carried on ahead by the upper wind, and in these cases the actual trough of low pressure, or the centre of the depression, may pass without thunder. Upper wind observations are certainly valuable for forecasting the time of arrival of such storms. A rather remarkable case occurred on May 20th-21st, 1932. There was a widespread outbreak of storms during the night of the 20th, and storms passed rapidly from south-south-west over parts of London at about 22h. (G.M.T., when the surface wind was just beginning to back to east, well ahead of a diffuse warm front. The centre of the depression passed next day, and at about 11h. there was a temperature difference of 18°F. within 50 miles, but there was only a little local thunder during the morning, and the cold front then crossed south-east England without thunder. In London the weather remained fine at the first cold front, but rain commenced about six hours later and was heavy and continuous for twelve hours (21 mm. at Kew) with a WNW. wind in the lower layers.

6. *Classification of Thunderstorms.*—Thunderstorms depend on so many factors over so great a range of height that there is no satisfactory basis for a classification. An elaborate classification would be possible but futile. For practical purposes it is useful to distinguish between diurnal convective storms and the various other types, but it must be remembered that instability is always developed near the ground by a few hours of summer sunshine, but that thunderstorms only form when conditions higher up are suitable. It is not by classification, but rather by the intensive study of individual cases, that progress may prove possible. The large mass of data being collected by Mr. S. Morris Bower should prove useful, especially in the area where the network of observations is close.

## Summer Thunderstorms

The annual census of summer thunderstorms in the British Isles will be commenced on April 1st next. The assistance of readers in recording storms will be very much appreciated. The details required remain materially the same as last summer. A note of the date and time of the observation of thunder, lightning or hail, with the direction in which the lightning was seen, especially at night, will be very valuable. In the case of actual thunderstorms additional information of the following character will be welcome:—

1. Time of first observation of thunder or lightning, with direction and estimated distance.
2. Time of commencement of very heavy rain or hail, or approximate time of nearest approach of storm, with direction and estimated distance.
3. Approximate time of final observation of thunder or lightning with direction.
4. Severity of storm; changes in direction or strength of wind, changes in temperature, &c., during the storm.

The shortest note for any of the days is valuable; it is not anticipated that every observer will fully record each storm.

It is essential that the place from which the record is made should be specified by mentioning the approximate distance and direction from a railway station, or otherwise, and that the standard of time used should be stated.

In thanking all those who were good enough to send in data last year, I may mention that the report is in preparation and will be forwarded to observers in the course of summer.

S. MORRIS BOWER.

*Langley Terrace, Oakes, Huddersfield. March 11th, 1938.*

## Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday evening, March 15th, at 49, Cromwell Road, Prof. S. Chapman, F.R.S., President, in the Chair. As is customary in March the meeting took the form of a lecture (The Symons Memorial Lecture), which was delivered on this occasion by Mr. P. M. S. Blackett, M.A., of the Cavendish Laboratory, Cambridge, his subject being

### *Cosmic Radiation.*

The study of what is now known as cosmic or penetrating radiation began over 30 years ago with the experimental investigation of the conductivity of the air in closed vessels. By 1932 measurements of the ionisation had been carried out up to heights of 28 kilometres in the atmosphere and down to depths of 230 metres under water. The ionisation is found to be 100,000

times more intense at the highest point reached compared with that at the greatest depth. More than 400 papers have been written on the subject and still the nature of the primary radiation is not certain and its origin quite unknown.

The ionisation is constant in time to within 2 per cent at any one place, but is about 12 per cent less intense at the equator than in latitudes of  $50^{\circ}$  N. and S. From these latitudes to the poles it is nearly constant. It is probable, but not certain, that the primary radiation incident on the earth's atmosphere consists of an isotropic corpuscular radiation with a mean energy of more than  $10^{10}$  volts.

The actual ionisation at sea level is due to fast particles, mainly electrons, protons and "positive electrons." The tracks of these particles can be photographed by the Cloud Method and such photographs have shown that very complex phenomena of great variety and interest occur in connexion with the absorption of the primary cosmic rays by matter. Many theories have been put forward to explain the origin of these rays but no one seems to fit the known facts.

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## OFFICIAL NOTICE

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### Course of Training for Observers

Provided enough applications are received, a course of training for meteorological observers at climatological stations will be held at the Meteorological Office, Exhibition Road, South Kensington, on Tuesday and Wednesday, May 9th and 10th, 1933. The Course will deal with ordinary climatological work, but not the special work carried out under the Crop Weather Scheme.

Subject to limitations of space the Course will be open to all climatological observers and deputy observers in connexion with the Meteorological Office. There will be no fee, but travelling and other incidental expenses incurred by observers attending the Course will in no case be paid by the Meteorological Office. Applications for admission to the Course should be made at once to The Director (M.O.7), Air Ministry, Kingway, London, W.C.2, from whom further information about the Course may be obtained.

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## Correspondence

To the Editor, *The Meteorological Magazine*.

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### Spells of Sunshine

In comparing rainfall statistics we nearly always include figures relative to Rain Spells, Dry Spells, etc., and in analysing sunshine in this district for the past 30 or more years I have been trying to employ similar terms in relation to sunshine.

Sunshine figures are sometimes misleading. In December,

1932, the sunshine here amounted to 30.4 hours, while the normal is 22 hours, thus giving an excess of 38 per cent.; but in that month there was a period from the 9th to the end during which the only recordable sunshine was limited to eight days and only on two of these exceeded one hour.

I have not come across any attempts to classify sunshine records in a similar manner to the terms employed in rainfall and I had in my mind to use the following:—

Sunny Period ...	30 days on all of which there was recordable sunshine.
Bright Period ...	15 days each of which had one hour or more of sunshine.
Dull Period ...	15 days not having one hour or more of sunshine.
Sunless Period ...	10 days with no recordable sunshine.

If anyone has done anything along this line I will be pleased to hear what periods, etc., were employed

WILLIAM DUNBAR.

17, *Kay Park, Kilmarnock.* January 10th, 1933.

### Large Hailstones

The following note in the second parish register book of St. Thomas, Southwark, may be of interest:—

"There was Hail stones fell in Mr. Locke's yard the 18th day of May 1680 taken up and measured in circumference 5 ynches and 3 quarters, and by report bigger was taken up in severall places in Southwark.

Gor. Locke."

W. H. CHALLEN.

69, *Brambledown Road, Carshalton.* February 7th, 1933.

### Frostless Periods at Abergele

The winter mildness of the North Wales coast is well known, but the following results of observations made here during the last 13 years may be of interest. My thermometers are certified and placed in a standard Stevenson screen:—

(1) Any month at any season of the year is liable to have no screen frost at all.

(2) Throughout the period we have had only three Octobers and only six Aprils with any frost.

(3) We have never registered frost between April 17th and October 25th, both inclusive; i.e., a period of 192 consecutive days without frost.

(4) The absolute minimum during the 13 years has been 15.3°F. on February 15th, 1929, and during the period there have been only 10 occasions when the temperature has fallen below 25°F. (8 of these being in February, 1929).

The remarkable mildness of Abergele may be due in some



degree to the configuration of the country and to the adjacent wooded limestone hills.

I expect that Holyhead and possibly parts of the Pembroke-shire coast can surpass Abergele as to mildness, but apart from those districts, it would be interesting to know whether any place north of Devonshire can do so.

SYDNEY WILSON.

*Trem-y-Coed, Sea Road, Abergele. March 4th, 1933.*

### Great Diurnal Range of Temperature

During the recent spell of anticyclonic weather a diurnal range of temperature in excess of  $40^{\circ}\text{F.}$  was registered at this valley station on four successive days, March 26th-29th, and on March 28th there was a rise amounting to  $47.7^{\circ}\text{F.}$  within eight hours—the greatest yet noted here. In the standard Stevenson screen a minimum of  $19.2^{\circ}\text{F.}$  during the early morning was followed just before 13h. 30m. by a maximum of  $66.9^{\circ}\text{F.}$  The thermograph, which is exposed near-by in an old-pattern Stevenson screen of smaller size and more open construction, showed a still greater increase—from  $19^{\circ}\text{F.}$  at 5h. 30m. to  $68^{\circ}\text{F.}$  at about 13h. Hitherto the most extensive diurnal range given by the standard thermometers since the installation of the station four years ago was  $46.7^{\circ}\text{F.}$ , on September 27th, 1929.

Relative humidity from the dry bulb and wet bulb readings was as low as 23 per cent. at 14h. on March 28th. The morning minimum by the radiation thermometer over short grass was  $12.7^{\circ}\text{F.}$ ; the solar maximum (black bulb in vacuo) reached  $131.7^{\circ}\text{F.}$  by 13h., but fell more than  $20^{\circ}\text{F.}$  during the next hour with the arrival overhead of the northern fringe of a London smoke-haze.

At 11h., though the screen temperature stood at  $62.1^{\circ}\text{F.}$ , storage cans of rain water, kept in the shade, still contained a considerable amount of ice. Incidentally, the garden was found littered with scores of dead earth-worms at 9h. These are believed to have been destroyed by the severe frost during the hours before sunrise, when they must have been prevented by the frozen state of the soil from re-burrowing after their nocturnal travels.

E. L. HAWKE.

*Canwood, The Valley Road, Rickmansworth, Herts. April 3rd. 1933.*

### Beginning of Spring—and other Seasons

I do not think that anyone could spend much time in the endeavour to frame a logical scheme for delimiting the boundaries of the seasons without reaching the final conclusion that the quest is futile and the problem intractable for two reasons: firstly, because it is so much a matter of definition; and secondly,

because the seasons are essentially overlapping periods, especially in a maritime climate like ours where every season is very long-drawn. In fact, so effectively does autumn join hands with spring through the depth of the open English winter, that almost every year reports from the shires appear in the Press of December primroses in token of the "extraordinary mildness of the season." In short, there is no precise date for the commencement of spring with any more significance than a human convention.

As regards the more general question, I do not think it is fully realised that if the average coldest part of the winter coincided with the darkest part, that is with the winter solstice, if the hottest period of summer were symmetrical with the lightest that is centred on the summer solstice, and if the value of its mean annual temperature were crossed precisely at the spring and autumn equinoxes, there would be no problem at all. It is the fact that the seasonal quarters as arranged by temperature lag a month behind the quarters as arranged by the duration of daylight and intensity of sunshine that makes the subject so debatable. Both temperature and light are important criteria in regard to living creatures. Thus February, though belonging to the winter quarter on the score of the cold, is in the spring quarter according to the light, whilst May, though too cool to be placed in the summer quarter, has precedence over August on the basis of long days and powerful sunshine.

The seasonal quarters adopted by meteorologists, viz., spring: March, April, May; summer: June, July and August; autumn: September, October and November; winter: December, January and February; rest upon a thermal basis, and though not perfect compromise better with other criteria than could any other arrangement of months.

L. C. W. BONACINA.

35, Parliament Hill, London, N. W. 3. March 25th, 1933.

### World's Altitude Record Flight

I was especially interested in the meteorological conditions during the World's Altitude Record Flight, as published in the *Meteorological Magazine* for February, p. 13. May I congratulate those concerned with the publication of the figures, on their promptness, as usually the chief snag lies in the fact that such, if published at all, are usually too late to revive interest.

I may mention that during the test of September 7th fine specimens of cirrus cloud were made by the exhaust gases, but referred to in local papers as "clouds of smoke," and the spectacle from a meteorological interest was very fascinating.

The report given in the *Meteorological Magazine* later deals

with the report of clouds up to 35,000 ft. on September 16th, and although the writer does not intend to convey that cirrus should have been reported from this area, I feel that it is only justice to state that his evident theory of haze is correct. At 7h. visibility at this station two miles from the aerodrome was only 550 yds., wind ENE., force 2 with 8-10ths of cumulus cloud from east to ob morn. b, b, afternoon with haze or high fog, to c, b, m, at 18h. visibility 1,100 yds., wind NE., force 2 with 6-10ths of cumulus cloud, from the south and, as usual here, followed by dense fog on the morning of the 17th (7fo).

G. H. BROWN.

*Parkstone Avenue, Horfield, Bristol. March 2nd, 1933.*

### The Duration of a Lightning Flash

In the December issue M. McCullum Fairgrieve reproduces a ciné film from which he deduces evidence of lightning flash duration of approximately  $5/8$  sec. In this connexion the following extracts from some notes made on a storm at Windsor, July 20th, 1929, and not hitherto published, may be of interest to your readers. These observations were made during the approach of a storm from the south-east and shortly before it passed overhead.

Most of the lightning appeared to be of the down-to-earth zigzag, unbranched type, most flashes consisting of several distinct discharges occurring in rapid sequence down the same channel or near it, the time interval between discharges being of the order of  $1/10$  sec. Two especially interesting cases were noted occurring probably within a mile of the point of observation, in which apparent incandescence of the air around the path of the flash took place. It appeared that the initial discharge consisted of a brilliant silver thread surrounded by an orange-red glow about 10 times the thickness of the central "thread." This red glow persisted for about  $\frac{1}{2}$  sec., during which time 6 or 7 "silver threads" passed through its centre, the glow disappearing almost immediately the last "thread" had passed.

Had a ciné film been taken of most of the flashes observed during this storm as recorded above, several successive exposures of the film would have shown tracks of the flash, very similar to those shown by Mr. Fairgrieve, since the rate of exposure of successive film areas would have been slower than the time interval between discharges. I would suggest therefore that what is regarded as evidence of a discharge of  $5/8$  sec. duration may be in reality a number of short duration discharges along the same path occurring at a greater frequency than  $1/16$  sec. This would also be more in agreement with results of radio observations on lightning flashes made at this station, which suggest

a single visible "flash" to be composed of a number of short discharges lasting a few thousandths of a second occurring at intervals at 1/100th to 1/10th of a second.

To obtain ciné film confirmation or negation of this conception it would be necessary to record at a speed of 100 to 200 pictures per second, a rate not beyond the possibilities of ciné-photography at the present time.

F. E. LUTKIN.

*Radio Research Station, Slough. January 11th, 1933.*

### **The February Snowstorm**

In your interesting article on the above, I see no mention of the Great Snowstorm of March 9th, 1891, which resembled the storm of the present year far more than that of January 18th, 1881.

I write from personal experience of both snowstorms, and in my opinion, so far as the south of England is concerned, the storm of last February is not to be compared for severity with either of the previous blizzards. For example, in January, 1881, London had such a heavy snowfall that snow was banked up against one's door so that it was impossible to get out without "digging one's way out"! In Sussex the drifts were from 8 to 10 feet deep, and I knew of a man who went out with a horse and cart from Worthing, whose vehicle got buried in a snowdrift, and he had to unharness the horse and return as best he could, the cart remaining in the drift for nearly a week. This February in the southern counties there was at most only about six inches of snow, which quickly melted as rain and sleet supervened.

The snowstorm of March 9th, 1891, chiefly affected the western counties, Devon and Cornwall being buried under snowdrifts for several days. London and the south generally had a lighter snowfall but very low temperatures.

Heavy snowfalls in the south and west of England are caused by a distribution of barometric pressure which is fortunately very uncommon, a rain-bearing depression from the Atlantic deflected from its usual course to the southward, drawing in cold Continental air, and thus producing snowfall instead of rain. Thus these "blizzards" are in this country generally associated with easterly or south-easterly gales, that of March 9th, 1891, being particularly severe.

DONALD W. HORNER.

*62, Canute Road, Olive Vale, Hastings, Sussex. March 27th, 1933.*

### **Snowstorms of February, 1933, and others**

Attempts to make categorical comparisons of big snowstorms, or for that matter other classes of storms, seem unwise because of

the many different aspects to be considered. In the 10-year supplement to my article in *British Rainfall*, 1927, I shall not put the case for the blizzard of February 23rd-26th, 1933, more strongly than to say that for area covered by deep snow it was one of the most severe in half a century. The snowstorm of January, 1881, which affected the southern half of Great Britain has been given relatively too much prominence in our meteorological annals mainly because it hit London; but there have been many equally severe snowstorms affecting areas just as great in the more northern parts of the country, all of which will be found recorded in my paper. It is doubtful whether the snowstorm of February, 1933, was more severe in Ireland than that of April, 1917. As regards considerable tracts of country in the south of England lying under deep snow there have been several months, particularly in the 1850's and 1870's, to surpass February, 1933, quite apart from the outstanding drifting blizzards of January, 1881, March, 1891 and December, 1927. In one respect the second week in February, 1900, is unique, since at least 1875, namely in the fact that the entire area of the British Isles lay under deep snow at the same time, due not so much to a particular blizzard, as to a succession of heavy snowfalls first in one district then in another.

All big blizzards, including February, 1933, have shown the interesting peculiarity of being preceded by heavy local snowfalls in areas which escaped the main storm.

L. C. W. BONAGINA.

85, *Parliament Hill*, London, N.W.3. March 26th, 1933.

## NOTES AND QUERIES

### Ball Lightning at Stoke Poges?

The *Slough, Eton and Windsor Observer* for March 10th contains an account of the destruction of a fir tree by lightning in the garden of Colonel and Mrs. Gordon Hall at Fairfield Lodge, Stoke Poges, on March 7th. An errand boy saw what he described as a ball of fire drop from the sky on to the tree, which immediately crumpled up. The tree was only a few feet from a corner of the house; fortunately it fell in the opposite direction, but pieces of wood weighing three or four hundredweight were thrown in all directions. One fell on the roof, making a large hole, and other pieces were found two or three hundred yards away. Mrs. Gordon Hall, who was shutting a window about six feet from the tree, was deafened and did not regain her hearing for two hours.

### Lunar Corona seen from Stornoway

Mr. A. F. Owen of H.M. Coastguard Station, Stornoway, Isle of

Lewis, has sent the following description of a lunar corona he observed from there at 2h. 30m. on March 10th, 1933. The diameter of the corona was approximately  $18^{\circ}$ . The central part next the moon was coloured from white to reddish brown. This was surrounded by a circle of colour, light blue on the inner side and light green on the outer side. Surrounding this again came further circles of colour in the following order, light brown, dark brown, dark green, light green and light blue, dark brown, light brown with very light rim a "brownish-white" on the outside. The brown shade was distinctly noticeable three times, inner, midway and outer circles. At 4h. the corona became very indistinct, only two inner colours showing reddish brown and light blue and light green. At 4h. 10m. the moon was obscured by clouds. At 2h. 30m. the wind was S. force 6-7 and the sky 6/10ths covered, there being much cirrus, visibility 10 miles.

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### Accessories for use with the Dines anemograph

Soon after the adoption of the Dines anemograph by the Meteorological Office the plan was introduced of showing on the charts, in addition to the rulings for multiples of 10 miles per hour, scales by which the strength of the wind according to the Beaufort scale could be read. These scales were set out according to the velocity equivalents adopted in 1906. The observer having an anemograph provided with such a chart has been able to read off the Beaufort number without concerning himself with the wind velocity in miles per hour.

According to the new convention of the Meteorological Office, the equivalents of the Beaufort scale depend upon the exposure of the head of the anemograph, and as the printing of special charts for various exposures is not to be recommended some alternative method of reading the strength of the wind was required. The need has been met by the provision of a pointer which slides along an upright fixed to the top place of the recorder of the anemograph. As will be seen from the illustration (see frontispiece of this number of the magazine), the upright is graduated in miles per hour on one side and according to the local Beaufort scale on the other. The pointer can be swung out of the way when the chart is being changed or the pen adjusted.

The first pointer of this kind was made in the Kew Observatory workshop for the anemograph which is above the dome of the Observatory. The height of the vane above the ground is 76 ft. The "effective height" adopted for the anemograph is 50 ft. Similar pointers have now been made for use at the meteorological stations at Croydon and Holyhead and Birmingham.

Attention may be called to another accessory which is to be seen in the illustration and which also serves to facilitate direct

readings of the Dines anemometer. This is a drum, with suitable graduations, fixed to the spindle of the direction recorder. A fixed vertical rod tapered at the top end acts as an index to show the direction of the wind. This accessory is now standardised by the makers of the anemograph, Messrs. R. W. Munro.

F. J. W. WHIPPLE.

## Obituary

*Captain William Gillon.*—We regret to announce the death, at Edinburgh, on March 25th, 1933, of Captain W. Gillon, M.A., B.Sc., Senior Professional Assistant in the Meteorological Office, Air Ministry.

Captain Gillon was born at West Calder, Fifeshire, in September, 1889, and was educated at Edinburgh University, where he graduated with first-class honours in Mathematics and Natural Philosophy. Early in the war he was commissioned as Sub-Lieutenant in the Royal Naval Volunteer Reserve, and was afterwards transferred to the Meteorological Service of the Royal Air Force with the rank of Captain. He joined the staff of the Meteorological Office as Senior Professional Assistant in January, 1920, and, after serving in the Forecast Division at Headquarters, was posted to the Isle of Grain, where he was in charge of the meteorological station attached to the local Royal Air Force unit. Thereafter he remained in charge of meteorological stations at Royal Air Force units serving successively at Leuchars, Aldergrove and finally Catterick, where he was stationed when he died.

Although of a reserved nature, Captain Gillon was always popular with his staff and with the Royal Air Force personnel with whom he came in contact. While, during his service in the Meteorological Office, he did not make any outstanding contribution to scientific knowledge, his professional work was always of a high order and he gave proof from time to time of the ability to which his qualifications bore testimony. His chief relaxation was golf, to which sport he was much attached.

*Dr. Robert Thorburn Ayton Innes.*—We regret to learn of the death of Dr. R. T. A. Innes, formerly Union Astronomer in South Africa, on March 13th, 1933. Dr. Innes was born in Edinburgh on November 10th, 1861, and educated in Dublin, becoming a fellow of the Royal Astronomical Society in 1879. He soon became known as a double star observer of repute, and in 1896 he went as secretary to Sir David Gill at the Royal Observatory, Cape of Good Hope. In 1903 he was appointed to be the first Director of the newly established Transvaal Observatory at Johannesburg, where he was in charge of meteorological as well as astronomical observations. He was a fellow of the Royal Meteorological Society from 1903-12, and contributed papers to the *Quarterly Journal* on the Climate and Rainfall of

South Africa. Other meteorological papers by him are "The barometer in South Africa" and "Transvaal sea-level temperatures." The University of Leyden gave him the D.Sc. (*honoris causa*) for his astronomical work. He retired early in 1928.

### News in Brief

The Brazilian Meteorological Service will in future be known as the Instituto Meteorologia, Hidrometria e Ecologia Agricola. Mr. R. P. Xavier, who succeeded Dr. Sampaio Ferraz as Director in February, 1931, has retired owing to ill-health, and Mr. C. de A. Martins Costa has become Director.

Prof. J. Proudman, Director of the Liverpool Observatory and Tidal Institute, and present holder of the Chair of Applied Mathematics in the University of Liverpool, has been elected to the Chair of Oceanography in the same University.

### The Weather of March, 1933

Pressure was above normal over Europe (except for the western British Isles), the Mediterranean, Spitsbergen, western Greenland, northern and western Canada, Alaska and the Mississippi Valley, the greatest excesses being 6.3 mb. at Prague and 9.1 mb. at Kodiak. Pressure was below normal over western Siberia, the North Atlantic, south-eastern Canada, north-eastern and most of western United States, the greatest deficits being 9.0 mb. at 50°N., 30°W. and 5.3 mb. at Ekaterinburg. Temperature was above normal over Europe with the exception of the Iberian Peninsula. In Sweden, it was normal in northern Norrland and 4°-5°F. above normal in other parts of the country. Rainfall was deficient at Spitsbergen and generally 15 per cent. below normal in Sweden.

Sunshine and warmth were the outstanding features of the weather of March over the British Isles. At Kew the total sunshine was 70 per cent. above the average, and has only once been exceeded (in 1907) since 1881; and at Birmingham (Edgbaston) the total was 64 per cent. above the average. High day maximum temperatures were followed by frequent ground frosts at night. During the opening days of the month the weather was unsettled with rain at times, slight in most places, but heavier in south-west Ireland and south-west England; 1.77 in. fell at Holne (Devon) on the 2nd. On the 4th, the complex low pressure area off our south-west coasts began to move northwards, giving easterly gales in north Scotland on the 4th, but the weather continued unsettled. Rainfall was moderate to heavy on the 5th and 8th locally, 1.64 in. fell at Treacastle (Brecon) on the 5th and 1.20 at Valencia on the 8th, and thunderstorms occurred on the 6th and 7th in the south and midlands, while snow was reported from the Shetlands and Highlands of Scotland on the



4th, 5th and 6th. On the 9th the British Isles came under the influence of the anticyclone over the continent, and a succession of fine, warm days and occasional night frosts followed until the 14th; 67°F. was reached at Collumpton and 65°F. at Bournemouth on the 13th, and 10·4 hrs. of bright sunshine were registered at Edinburgh, Collumpton and Armagh on the 11th and at Jersey on the 12th. On the 15th depressions from the Atlantic with vigorous secondaries caused a return to unsettled conditions for a time with gales in the English Channel on the 16th and 19th, and in north Ireland on the 16th. There was rain or heavy showers in all districts, and hail and thunderstorms in south Ireland and south and north-east England on the 17th-19th, but there were long sunny periods, and in the south temperature continued generally above normal. Snow and sleet were experienced in Scotland, north Ireland and parts of Wales on the 18th-20th. The deep depression over the Atlantic gave rain and occasional gales in the west and north on the 21st-23rd, but the anticyclone over Spain spread across the eastern British Isles on the 21st, and later over the west as well, and sunny, fine warm weather with night frosts inland prevailed generally until the 29th. Some remarkably good sunshine records were experienced, daily amounts being frequently between 10 and 12 hrs. Margate had over 11 hrs. each day between the 23rd and 29th inclusive. The day temperature of 70°F. at Aberdeen on the 28th was a record for March. A trough of low-pressure crossed the country on the 29th, and showers were prevalent on the 29th-30th, though long periods of bright sunshine were recorded in most places. In the rear of this trough temperature fell somewhat and hail was experienced locally and slight snow in Scotland. A thunderstorm occurred at Croydon on the 30th. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	88	—17	Liverpool	144	+36
Aberdeen	157	+40	Ross-on-Wyo	178	+62
Dublin	128	+ 5	Falmouth	181	+43
Birr Castle	118	+ 8	Gorleston	178	+43
Valentia	115	— 8	Kew	178	+78

The special message from Brazil states that the rainfall in the northern and central regions was scarce and in the southern regions very scarce, with an average 2·64 in. below normal. Six anticyclones passed across the country without, however, any particular change in the weather. The crops were in generally good condition on account of the favourable weather. At Rio de Janeiro pressure was 0·8mb. above normal and temperature 0·9°F. below normal.

*Miscellaneous notes on weather abroad culled from various sources.*  
The ice on the Danube below Galatz had broken up by the 3rd, and at Sulina the drift ice was running. A Hull trawler foundered off Hornö, near Vardö, in a heavy snowstorm at 1.30 a.m. on the 6th, five of the crew of 15 being lost. A heavy gale was experienced along the Anatolian coast of the Black Sea on the 8th. The river ice was moving at Riga on the 21st. A violent storm passed over Messina on the 22nd, but no casualties were reported. At Pori (Bjorneborg), Finland, navigation had opened by the 29th. (*The Times*, March 4th-30th.)

A dense sandstorm occurred over the Suez Canal on the 1st detaining all vessels. One person was killed and six injured by a tornado which struck Leopoldville (Belgian Congo) on the 6th (*The Times*, March 2nd-8th.)

Sandstorms were experienced by the Houston Mount Everest expedition between Baghdad and Bushire on the 4th, and one aeroplane of the expedition was lost in a sandstorm at Allahabad on the 12th. High winds at great heights prevented full trials of the expedition's aeroplanes during the closing days of the month. (*The Times*, March 6th-31st.)

Severe early frosts caused damage of over £50,000 to the tobacco crop in north-eastern Victoria. (*The Times*, March 23rd.)

A tornado approaching from Arkansas and Missouri swept across Tennessee on the night of the 14th-15th; 36 people were killed and about 200 injured. The damage was heaviest in Nashville, Harrogate and Jellico in Tennessee, and in Caruthersville in Missouri. The floods throughout the valley of the Ohio River were still rising on the 21st. Twenty-one people were killed and about 100 injured by tornadoes accompanied by thunderstorms which swept across east Texas, south-east Arkansas, and north-west Louisiana on the 30th. A spell of warm weather passed slowly across the United States from west to east during the first three weeks of the month, temperature was as much as 16°F. above normal at Williston (North Dakota) and Havre (Montana) during the week ending the 7th, and 12°F. at Augusta (Galveston) during the week ending the 21st. Later temperature was for the most part below normal. Rainfall was irregular in distribution at first, becoming above normal in the eastern States during the week ending the 21st, then below normal generally later. (*The Times*, March 16th-April 1st; *Washington D.C., U.S. Dept. Agric. Weekly Weather and Crop Bulletin*.)

### General Rainfall for March, 1933

England and Wales	...	119	} per cent of the average 1881-1915.
Scotland	...	64	
Ireland	...	99	
British Isles	...	<u>101</u>	

## Rainfall: March, 1933: England and Wales.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>London</i>	Camden Square .....	2.27	124	<i>Leis.</i>	Thornton Reservoir ...	2.09	102
<i>Kent</i>	Tenterden, Ashenden...	2.30	107	"	Bolvoir Castle .....	2.85	157
"	Folkestone, Boro. San.	1.77	...	<i>Kut</i>	Ridlington .....	2.71	150
"	St. Peter's, Hildersham	...	...	<i>Lines</i>	Boston, Skirbeck .....	2.28	140
"	Edon'bdg., Falconhurst	3.73	150	"	Cranwall Aerodrome ...	2.61	180
"	Sevenoaks, Speldhurst	2.90	...	"	Skegness, Marine Gdns	2.02	122
<i>Sus.</i>	Compton, Compton Ho.	4.03	145	"	Louth, Westgate .....	2.03	124
"	Patching Farm .....	2.49	110	"	Brigg, Wrawby St. ...	2.16	...
"	Eastbourne, Wil. Sq.	1.08	88	<i>Notts.</i>	Worksop, Huddock .....	2.01	154
"	Heathfield, Barklye ...	3.57	143	<i>Derby.</i>	Derby, L. M. & S. Rly.	2.27	132
<i>Hants.</i>	Vontnor, Roy. Nat. Hos.	2.78	130	"	Buxton, Terr. Slopes	3.46	84
"	Fordingbridge, Oaklands	4.17	179	<i>Ches.</i>	Runcorn, Weston Pt. ...	1.99	90
"	Ovington Rectory .....	4.02	180	<i>Lancs.</i>	Manchester, Whit Pk.	2.70	123
"	Sharborne St. John ...	3.04	180	"	Stonyhurst College ...	2.08	73
<i>Herts.</i>	Welwyn Garden City ...	2.80	...	"	Southport, Heskestri Pk	2.20	99
<i>Bucks.</i>	Slough, Upton .....	2.64	144	"	Lancaster, Grog Obay.	2.23	70
"	H. Wycombe, Blackwell	3.10	...	<i>Yorks.</i>	Wath-upon-Dearne ...	2.70	159
<i>Oxf.</i>	Oxford, Mag. College...	2.20	144	"	Walsford, Clarence Pk.	2.12	118
<i>Nor.</i>	Pittsford, Sedgbrook...	2.34	139	"	Oughtershaw Hall .....	4.24	...
"	Oundle .....	2.35	...	"	Wetherby, Ribston II.	1.87	96
<i>Beds.</i>	Woburn, Crawley Mill	2.42	141	"	Hull, Pearson Park ...	1.99	100
<i>Cam.</i>	Cambridge, Bot. Gdns.	1.74	118	"	Holme-on-Spalding ...	2.49	...
<i>Essex.</i>	Chelmsford, County Lab	1.64	95	"	West Witton, Ivy Ho.	2.93	75
"	Lexdon Hill House ...	1.62	...	"	Felixkirk, Mt. St. John	1.89	96
<i>Suff.</i>	Haughley House .....	1.80	...	"	York, Museum Gdns.	2.06	123
"	Campsea Ash .....	1.63	97	"	Pickering, Hungate ...	2.51	120
"	Lowestoft Sec. School	...	...	"	Scarborough .....	1.84	102
"	Bury St. Ed., Westley H.	2.27	120	"	Middlesbrough .....	1.41	90
<i>Norw.</i>	Wells, Holkham Hall	1.92	118	"	Baldersdale, Hury Res.	2.57	83
<i>Wilts.</i>	Devizes, Highclere .....	2.73	130	<i>Durh.</i>	Ushaw College .....	1.27	58
"	Calne, Castleway .....	3.14	147	<i>Nor.</i>	Newcastle, Town Moor	1.08	51
<i>Der.</i>	Evershot, Melbury Ho.	5.25	178	"	Bollingham, Highgrove	1.09	37
"	Weymouth, Westham ...	3.18	162	"	Lilburn Tower Gdns. ...	.80	32
"	Shaftesbury, Abbey Ho.	2.71	115	<i>Cumb.</i>	Carlisle, Scalby Hall	2.79	114
<i>Devon.</i>	Plymouth, The Hoe ...	3.78	129	"	Borrowdale, Southwalto	...	...
"	Holne, Church Pk. Cott.	3.59	178	"	Borrowdale, Moraine ...	7.28	...
"	Teignmouth, Den Gdns.	4.06	166	"	Keswick, High Hill ...	3.88	86
"	Cullompton .....	3.59	181	<i>West.</i>	Appley, Castle Bank	1.70	67
"	Sidmouth, Sidmount ...	3.18	130	<i>Mon.</i>	Abergavenny, Larch ...	3.47	114
"	Barnstaple, N. Dev. Ath	2.98	114	<i>Glam.</i>	Ystalyfera, Worn Ho.	6.03	112
"	Dartm'r, Cranmere Pool	3.80	...	"	Ordliff, Ely P. Stn. ...	3.35	104
"	Okolhampton, Uplands	5.64	186	"	Troherbert, Tynywau	3.05	...
<i>Corn.</i>	Redruth, Trewlrgie ...	4.81	184	<i>Carm.</i>	Carmarthen Friary ...	3.40	91
"	Penzance, Morrah Gdn.	4.37	137	<i>Pemb.</i>	Haverfordwest, School	3.34	98
"	St. Austell, Trevaria ...	4.33	128	<i>Card.</i>	Abereystwyth .....	2.01	...
<i>Som.</i>	Chowton Mendip .....	4.88	128	<i>Rad.</i>	Birn W.W. Tyrmynydd	4.67	87
"	Long Ashton .....	3.71	146	<i>Mont.</i>	Lake Vyrnwy .....	3.71	87
"	Street, Millfold .....	2.34	114	<i>Wint.</i>	Sealand Aerodrome ...	1.95	100
<i>Glos.</i>	Blockley .....	2.47	...	<i>Mer.</i>	Dolgellay, Bontddu ...	3.30	98
"	Chenchester, Gwynfa ...	3.52	152	<i>Carm.</i>	Llandudno .....	1.50	72
<i>Here.</i>	Ross, Birchlea .....	2.60	128	"	Snowdon, L. Llydaw	9.82	...
"	Ledbury, Underdown ...	2.23	117	<i>Ang.</i>	Holyhead, Salt Island	2.13	83
<i>Salop.</i>	Church Strotton .....	3.09	181	"	Llwyg .....	3.40	...
"	Shifnal, Hatton Grange	2.24	122	<i>Isle of Man</i>			
<i>Staffs.</i>	Market Drayt'n, Old Sp.	2.68	126		Douglas, Boro' Cem. ...	3.34	112
<i>Worc.</i>	Ombersley, Holt Lock	1.91	112	<i>Guernsey</i>			
<i>War.</i>	Birmingham, Edgbaston	2.92	158		St. Peter P't. Grange Rd.	2.46	99

At Borrowdale, Southwalto for February and March 24.25 inches.

## Rainfall: March, 1933: Scotland and Ireland.

Co.	STATION	In.	Per- cent of Av.	Co.	STATION	In.	Per- cent of Av.
<i>Wigt.</i>	Pt. William, Monreith	1.02	07	<i>Suth.</i>	Molvich	1.00	50
	New Luce School	3.13	88		Loch More, Achnafary	2.80	44
<i>Kirk.</i>	Dalry, Glendarroch	3.78	84	<i>Caith.</i>	Wick	1.87	82
	Carsphairn, Shiel	5.45	90	<i>Ork.</i>	Deerness	2.58	02
<i>Dumf.</i>	Dumfries, Crichton, R.I.	1.08	70	<i>Shet.</i>	Lerwick	2.50	82
	Esksdalemuir Obs.	3.68	75	<i>Cork.</i>	Caheragh Rectory	5.05	...
<i>Roab.</i>	Branxholm	1.72	69		Dunmanway Rectory	4.09	06
<i>Selk.</i>	Ettleick Manse	4.00	80		Cork, University Coll.	2.78	03
<i>Peeb.</i>	West Linton	1.25	...		Ballinacorra	2.67	00
<i>Berw.</i>	Marholm House	1.01	38	<i>Kerry.</i>	Valentia Obsy.	6.67	146
<i>E. Lot.</i>	North Berwick Res.	0.89	47		Gearahameen	9.70	...
<i>Midl.</i>	Edinburgh, Roy. Obs.	0.88	45		Killarnoy Asylum	...	...
<i>Lea.</i>	Auchtyfawley	2.71	...		Dunrynanne Abbey	5.00	124
<i>Ayr.</i>	Kilmarlock, Kay Pk.	2.48	...	<i>Wat.</i>	Waterford, Gortmore	3.62	133
	Girvan, Plumora	2.35	75	<i>Tip.</i>	Nowlgh, Cas. Lough	3.68	119
<i>Renf.</i>	Glasgow, Queen's Pk.	2.42	93		Roseton, Timoney Park	2.30	...
	Greenock, Prospect H.	3.05	80		Cashel, Ballinamona	1.04	71
<i>Bute.</i>	Rothsary, Ardenoraig	3.10	...	<i>Lin.</i>	Foynes, Coolmanes	2.75	03
	Dougarie Lodge	2.41	...		Castleconnel Rec.	2.57	...
<i>Ary.</i>	Ardgour House	5.20	...	<i>Clare.</i>	Inagh, Mount Callan	4.15	...
	Glen Etive	...	...		Broadford, Hurdle's n.	3.76	...
	Oban	3.09	73	<i>Wex.</i>	Corey, Courtown Ho.	3.02	131
	Poltalloch	3.27	88	<i>Kilk.</i>	Kilkenny Castle	2.54	111
	Inveraray Castle	5.20	83	<i>Wick.</i>	Rathnew, Clonmannon	2.50	...
	Islay, Ballabus	2.08	78	<i>Carl.</i>	Hacketstown Rectory	2.84	101
	Mull, Benmore	...	...	<i>Leic.</i>	Blandsfort House	3.03	116
	Tiree	2.82	78		Mountmellick	3.80	...
<i>Kinn.</i>	Loch Loven Sluice	1.78	60	<i>Offaly.</i>	Birr Castle	3.32	138
<i>Perth.</i>	Loch Dhu	4.85	74	<i>Kild'r.</i>	Monasteravin	...	...
	Balquhadder, Stronvar	3.00	...	<i>Dublin.</i>	Dublin, FitzWm. Sq.	1.71	88
	Oriselt, Strathearn Hyd.	1.78	50		Bulbriggan, Ardglilan	2.04	101
	Blair Castle Gardens	1.41	54	<i>Meath.</i>	Beauparc, St. Glion	2.12	...
<i>Angus.</i>	Kettins School	1.50	02		Kells, Headfort	2.10	76
	Pearse House	2.48	...	<i>W.M.</i>	Monte, Coolatore	2.93	...
	Montrose, Sunnyside	1.69	70		Mullingar, Belvedere	2.05	98
<i>Aber.</i>	Braemar, Bank	1.57	53	<i>Long.</i>	Castle Forbes Glens	3.40	117
	Logie Coldstone Sch.	1.54	59	<i>Gal.</i>	Ballynahinch Castle	6.43	125
	Aberdeen, King's Coll.	2.00	83		Galway, Grammar Sch.	2.45	...
	Fyvie Castle	2.52	93	<i>Mayo.</i>	Mallacross	1.44	...
<i>Moray.</i>	Gordon Castle	0.68	20		Westport House	3.34	86
	Grantown-on-Spey	...	...		Delphi Lodge	3.37	101
<i>Nairn.</i>	Nairn	0.61	33	<i>Sligo.</i>	Markree Obsy.	3.98	117
<i>Inver.</i>	Ben Alder Lodge	1.75	...	<i>Carm.</i>	Belturbet, Cloverhill	2.05	74
	Kingussie, The Birches	1.08	...	<i>Fern.</i>	Beltiskillen, Portlora	2.09	...
	Loch Quoich, Loan	4.85	...	<i>Arm.</i>	Armagh Obsy.	2.01	85
	Glenquoich	...	...	<i>Down.</i>	Fossumy Reservoir	4.10	...
	Inverness, Culduthel R.	0.42	...		Seaford	2.00	09
	Arisaig, Fairs-na-Buidh	2.14	...		Donaghadee, O. Stn.	2.79	127
	Fort William, Glasdrum	4.70	...		Banbridge, Milltown	1.70	80
	Skye, Dunvegan	2.70	...	<i>Antr.</i>	Belfast, Cavell Rd.	2.60	...
	Barra, Skallary	3.00	...		Aldergrove Aerodrome	1.78	71
<i>R. &amp; C.</i>	Alnoss, Ardross Castle	1.52	47		Ballymona, Harryville	2.64	84
	Ullapool	1.30	33	<i>Lon.</i>	Londonderry, Oreggan	2.47	77
	Achnashellach	3.22	45	<i>Tyr.</i>	Omagh, Edenfel	2.88	02
	Stornoway	2.18	53	<i>Don.</i>	Malin Head	2.31	...
<i>Suth.</i>	Lairg	1.81	42		Millford, The Munse	3.20	07
	Tongue	1.83	54		Killybegs, Rookmount	2.41	47

## Climatological Table for the British Empire, October, 1932

STATIONS	PRESSURE			TEMPERATURE						Relative Humidity	Mean Cloud Amount	PRECIPITATION			BRIGHT SUNSHINE			
	Mean of Day M.S.L.	Diff. from Normal	mb.	Absolute		Mean Values						Amm't	Diff. from Normal	in.	Days	Hours per day	Per cent. age of possible	
				Max.	Min.	Max.	Min.	1/2 max. and min.	Diff. from Normal									Wet Bulb
London, Kew Oby.	1008.5	- 7.5	64	33	55.4	43.0	49.2	- 0.7	45.0	6.1	0-10	+	2.30	24	3.1	29		
Gibraltar	1017.7	+ 0.5	80	52	74.3	56.6	65.5	- 0.6	56.5	3.5	2-48	+	0.88	9	..	..		
Malta	1014.3	- 1.7	90	57	78.6	69.0	73.8	+ 2.3	68.6	5.9	5-67	+	2.80	9	7.4	65		
St. Helena	1015.6	+ 0.1	61	51	58.4	52.6	55.5	- 2.8	53.4	9.9	0-84	..	..	12	..	..		
Freetown, Sierra Leone	1013.5	+ 1.9	88	70	85.5	73.2	79.3	- 0.8	76.0	6.8	8-28	-	4.39	23	..	52		
Lagos, Nigeria	1012.3	+ 1.3	87	70	83.9	74.0	78.9	- 0.5	74.8	6.8	5-16	-	2.61	12	6.2	52		
Kaduna, Nigeria	1012.6	- 0.7	92	66	87.0	68.3	77.7	+ 1.4	71.9	8.5	7-85	+	5.10	14	7.3	61		
Zomba, Nyasaland	1010.7	- 0.2	90	52	85.3	62.4	73.9	+ 0.2	..	4.8	2-3	+	1.32	1	..	..		
Salisbury, Rhodesia	1012.1	+ 0.3	91	50	83.8	57.9	70.9	+ 0.2	57.1	3.8	1-8	..	1.10	1	9.4	75		
Cape Town	1018.4	+ 1.0	92	45	72.5	53.1	62.8	+ 1.6	55.1	6.7	4-6	..	0.82	7	..	..		
Johannesburg	1018.9	+ 1.4	86	41	76.7	58.2	64.9	+ 2.1	53.3	4.6	1-34	-	1.22	9	8.8	69		
Mauritius	1009.1	- 0.3	82	60	79.0	64.6	71.8	- 0.9	66.9	8.3	8-3	..	..	..	..	64		
Calcutta, Alipore Oby.	1009.1	- 0.3	94	63	80.0	76.4	83.2	+ 3.9	77.2	3.2	3-79	+	7.34	9*	..	..		
Bombay	1008.3	- 1.5	95	73	80.3	78.1	84.2	+ 1.6	77.4	8.3	5-7	+	10.48	10*	..	..		
Madras	1008.2	- 0.7	93	71	87.0	76.2	81.6	- 0.7	77.6	8.5	6-9	+	17.38	31	6.3	53		
Colombo, Ceylon	1009.8	- 0.2	86	73	84.3	74.9	79.8	- 0.7	77.4	7.8	7-6	+	4.50	21	5.5	45		
Singapore	1009.1	- 0.6	91	72	87.3	74.9	81.1	- 0.0	77.7	8.3	6-3	-	4.35	3	5.0	43		
Hongkong	1014.1	+ 0.4	86	66	80.7	72.8	76.7	- 0.2	69.0	6.5	6-3	-	3.21	17	..	..		
Sandakan	1013.3	- 1.5	90	72	88.8	75.2	82.0	+ 0.6	77.7	8.2	6-7	-	1.96	16	7.1	55		
Sydney, N.S.W.	1014.0	- 0.8	88	48	69.6	54.6	62.1	- 1.5	57.3	6.3	6-0	-	2.52	19	5.3	40		
Melbourne	1016.2	+ 0.2	83	38	64.8	45.6	55.2	- 2.5	51.6	6.5	7-3	+	0.59	15	5.0	39		
Adelaide	1015.5	- 1.3	88	43	67.3	49.2	58.3	- 3.7	52.0	5.5	7-6	+	1.21	12	8.8	69		
Perth, W. Australia	1014.6	- 0.5	90	42	72.7	48.8	60.7	- 3.0	52.9	5.4	4-0	+	2.15	12	..	..		
Coolgardie	1014.8	- 1.4	86	52	77.7	59.5	68.6	- 1.2	61.0	6.3	2-98	+	0.40	11	7.6	60		
Brisbane	1010.3	- 0.7	78	37	60.2	44.9	52.5	- 1.6	47.8	6.3	7-0	+	1.89	18	5.2	39		
Robert, Tasmania	1016.6	+ 3.5	67	41	59.9	48.2	54.1	- 0.3	52.2	7.6	3-87	-	0.21	14	5.6	42		
Wellington, N.Z.	1013.7	+ 0.5	92	68	83.2	72.8	78.0	+ 2.2	73.0	7.4	8-35	+	0.06	17	5.0	40		
Suva, Fiji	1011.1	- 0.4	88	70	85.7	74.5	80.1	- 1.7	76.4	7.3	5-0	+	0.39	14	8.0	65		
Apia, Samoa	1010.9	- 0.6	92	69	87.6	73.1	80.3	- 0.2	72.6	8.8	5-2	-	2.64	14	7.2	61		
Kingston, Jamaica	1014.9	- 2.6	..	..	..	..	..	..	..	..	..	..	..	..	..	..		
Grenada, W.I.	1016.6	+ 1.7	73	33	58.6	44.1	51.3	+ 2.7	46.0	6.4	6-4	-	0.78	9	4.4	40		
Toronto	1016.8	+ 0.8	70	12	44.1	29.7	36.9	- 3.8	..	7.8	1-96	+	0.59	9	2.1	29		
St. John, N.B.	1018.3	+ 1.7	76	40	57.2	47.1	52.1	+ 1.8	49.8	6.4	4-29	-	0.25	14	4.4	37		
Victoria, B.C.	1018.3	+ 1.7	76	40	57.2	47.1	52.1	+ 1.8	49.8	7.2	2-31	-	0.23	15	4.0	..		

\* For Indian stations a rain day is a day in which 0.1 in. or more rain has fallen.

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## A Beautiful Reflected Rainbow

The following account of an unusually complete reflected rainbow is translated from *Onweilers, optische verschijnselen, enz. in Nederland*, vol. 51, 1930, pp. 74-7, by kind permission of the Director of the Koninklijk Nederlandsch Meteorologisch Instituut.

"On November 29th, 1930, Heer M. D. Dijt, of Eierland, Texel Island, observed a reflected rainbow, of which he gave so accurate a description that every phase of this unusual phenomenon can be followed.

To quote Heer Dijt:—

'The rainbow was observed at Eierland, Texel Island. I was at the point marked 1 on my diagram (Fig. 2). At about 13h. it began to rain, whilst there was practically no wind. To the south-west the sky was clearing and the 'clearing line,' which extended all along the horizon, appeared very slowly. Behind the clearing line the sky was clear. When the sun appeared at 14h., just below the clearing line, I went out of doors to have a look at the rainbow I expected to see, and was astonished to see three bows, one above the other, as shown in Fig. 1. At first bow C was even brighter than bow A, and bow B was very faint. The reds of A and C were on the outer edge of the bows and the red of B was on the inner edge. Bows A and B slowly grew brighter so that the effect, especially of A was brilliant at

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14h. 10m. and after. At the time in question I could differentiate the following sequences of colours: in A, from the outer to the inner edge; red, orange, yellow, green, blue, violet, green, violet, green, violet; in B, from the outer to the inner edge, violet, green, yellow, red; and in C, red, yellow, green. After this C disappeared.

I was unable at first to understand the appearance of bow C, as I knew there were no expanses of water within 2 kilometres, but I think the phenomenon may be explained by the sheets of water at Waal and Burg, 2 to 4 kilometres distant. Thanks to the absolutely still air these sheets of water, which at that time, owing to the floods, extended over a wide area (shaded parts of Fig. 2) constituted giant mirrors and reflected the sunlight on the rainclouds and falling rain over the Eierland polder about 3 to 5 Km. distant from the sheets of water. As the sun was

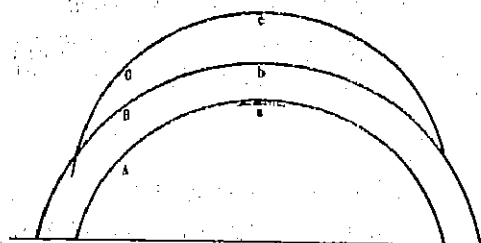


FIG. 1. REFLECTED RAINBOW SEEN FROM EIERLAND ON NOVEMBER 29th, 1930.

relatively low, the diffusion of light over such a great distance is explicable. At 14h. the centre of the highest part of bow A, indicated by 'a' in Fig. 1, was about  $31^\circ$  above the horizon, the highest part of bow B,

indicated by b in Fig. 1 was about  $39^\circ$ , and the highest part of bow C, indicated by c, about  $50^\circ$  above the horizon. I had only a post and a couple of sticks wherewith to measure these heights. If I am not mistaken in my measurements and my assumption that bow C was caused by the sun reflected by the water is correct, the height of the sun

must have been approximately  $10^\circ$ , i.e.,  $\frac{50-31}{2}$ . The sudden fading away of bow C at 14h. 10m., whilst the brilliance of bows A and B was increasing is, in my opinion, due to the fact that an easterly wind set in at that moment and ruffled the smooth surface of the water.

I was informed that this phenomenon was likewise observed at the place marked 2 on Fig. 2. I think it probable that all three rainbows may have been observed at other places north-east of the expanses of water.

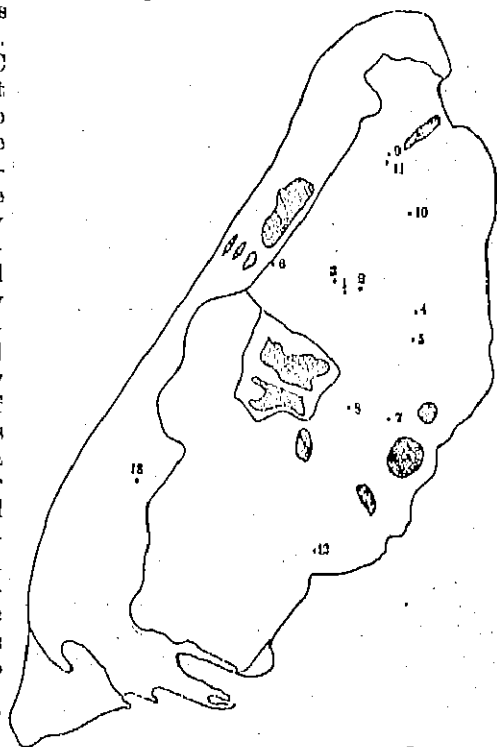
Heer Dijt's explanation is undoubtedly correct, and he is to be congratulated on the fact that he was able to take such accurate measurements with the rough-and-ready means at his disposal. At 14h. 5m. the sun was  $9^\circ 48'$  above the horizon. The radius of the normal rainbow A must have been  $42^\circ$ , that of bow B  $50^\circ$ ,

hence theoretically, a must have been  $32^{\circ} 12'$ , b,  $40^{\circ} 12'$ , and c,  $51^{\circ} 48'$  above the horizon.

It is possible that the wind referred to by Heer Dijt actually was the cause of the sudden fading of the reflected bow. The higher bow should have faded first with the passage of the rain squall, but it would have faded slowly and not suddenly. It is impossible from the data to determine the height of the cloud base at the time of observation, but it must have been at least 1,000 metres.

If we consider the path of the reflected rays when the sun is  $10^{\circ}$  above the horizon, it is obvious that the pencil of rays was more than wide enough for a complete reflected bow to be visible from Heer Dijt's point of observation.

To explain that C could be followed at a height of  $25^{\circ}$  to  $30^{\circ}$ , we must assume that the southerly expanses of water were also a contributory cause. The completeness of the reflected bow with a relatively small reflecting surface maybe explained by the unusually favourable point of observation. This was confirmed by a number of other observations received by Heer Dijt subsequent to an appeal for observations published in the *Tweelste Courant*. The points of observation are given in Fig. 2. 1 represents that of Heer Dijt. The obser-



vers at 2 and 3 close by, saw the same phenomenon as Heer Dijt, those at 4 and 5 saw the ordinary bow perfectly but only a part of the reflected bow to the left, and those at 6 saw it only to the right. 7 and 8 are in the direction of the sun's rays in relation to a few smaller expanses of water; 7 saw the highest middle section of the reflected bow, 8 described a third bow on the ground; this,

FIG. 2. SKETCH OF AREAS UNDER WATER ON TEXEL.



however, was probably due to his imagination. It is more difficult to explain 9-11 and 12. In the case of 9 and 11 the expanses of water along the west coast may possibly have contributed. Both 9, 11 and 12 state that they only saw a portion of a reflected bow on the left edge. 10, however, describes a completely reflected bow. This might be due to the stretches of water at Waal and Burg; in that case the rays descending with the inclination  $50^\circ$  must have been reflected by drops at a height of about 1,000 metres. 12 was probably due to some small local expanse of water, Heer Dijt was not certain that he knew every spot under water. Observation 13 was sent to us direct by the observer, Heer A. Koopman. If we understand his diagram aright he saw the right lower end of the three bows, and the reflected bow between the other two ended slightly higher and was steeper. This portion may actually have been caused by the rays reflected by the expanses of water between observation points 7 and 12.

The 14th observation from Wieringen can naturally not be ascribed to the expanses of water on Texel Island, but probably to the parts of the Wieringermeerpolder which, owing to the constant rain, were again flooded. The whole phenomenon would, therefore, appear to be due to the excessive rainfall in November."

## Remarkable Sunshine Record of Tiree

By J. CRICHTON, M.A., B.Sc., F.R.S.E.

At Cornaigmore School, Tiree, a telegraphic station has been maintained by the Meteorological Office for several years, sunshine values being available for the period 1927-1932. A study of the sunshine maps given in the "Book of Normals of Meteorological Elements of the British Isles" for periods ending 1915 would lead one to expect that Tiree on the average would experience very little sunshine throughout the year. An examination of the annual summaries of sunshine duration at various stations throughout the British Isles, issued by the Meteorological Office, indicates, however, that Tiree enjoys during at least the months of April, May and June as much sunshine as any part of the British Isles.

In Table I we have for a few stations the mean daily values of sunshine duration for each month and for the year over the period 1927-1932, the stations selected, with the exception of Stornoway, Castlebay and Tiree, comprising all those with 25 or more years' record which have been used in compiling the maps in the "Book of Normals" and for which data were given in the annual sunshine duration summaries. Stornoway and Castlebay were included for purpose of comparison, as

TABLE I

Mean monthly and annual sunshine daily averages covering period 1927-1932, with annual normal daily values for standard period 1881-1915.

	East- bourne	Silly	Bright- on	South- ampton	Ply- mouth	Douglas	Dublin	Green- wich	Kew	Valen- tia	Aber- deen	Storn- oway	Castle- bay*	Tiree
January	2-00	2-19	1-98	1-82	1-97	1-92	1-96	1-18	1-48	1-43	1-89	0-96	0-89	1-18
February	3-26	3-21	3-43	2-63	3-01	2-74	2-52	1-69	1-92	2-60	2-46	2-27	1-90	2-48
March	5-09	4-74	5-02	4-22	4-59	4-17	3-79	3-80	3-89	4-04	3-28	3-70	3-69	4-06
April	5-68	6-07	5-47	4-67	5-47	5-45	4-99	3-96	4-34	4-71	4-41	5-24	5-64	6-44
May	7-12	6-75	6-82	5-99	6-01	7-09	5-77	5-40	5-77	6-28	4-87	6-23	6-34	7-78
June	8-14	7-62	7-65	7-15	7-30	7-10	6-33	6-40	6-63	5-81	6-05	6-09	6-06	7-46
July	7-62	6-75	7-17	6-39	6-32	5-46	4-59	5-99	6-11	4-02	4-45	3-88	5-43	7-46
August	7-23	6-64	6-72	6-01	6-00	5-36	4-67	6-07	5-98	4-58	4-42	4-49	4-50	5-14
September	5-30	5-49	5-61	5-19	5-33	4-89	4-22	4-61	4-64	4-32	3-95	3-50	3-76	4-02
October	4-05	4-13	4-00	3-61	3-80	3-60	3-72	3-01	3-18	2-79	3-22	2-44	2-57	2-79
November	2-36	2-38	2-32	2-15	2-24	2-09	2-36	1-40	1-72	1-97	2-15	1-62	1-45	1-70
December	1-80	1-76	1-81	1-49	1-86	1-26	1-41	0-98	1-29	1-14	1-26	0-77	0-77	0-99
Year	5-00	4-84	4-84	4-28	4-47	4-27	3-87	3-72	3-93	3-64	3-54	3-41	3-59	4-07
35 year nor- mal	4-88	4-84	4-81	4-57	4-56	4-41	4-13	4-05	4-04	3-96	3-80	3-45	—	—

Maximum values are indicated by heavy type.

\* Values refer to period 1908-1926.

TABLE II

Mean monthly and annual sunshine daily averages covering period 1927-1932, with mean normal daily values for year for period 1881-1915 expressed as a percentage of mean length of day, allowances having been made in length of day for periods when sun had an elevation of 3° or less.

	East-bourne	Sally	Brighton	South-ampton	Ply-mouth	Douglas	Dublin	Greenwich	Kew	Valentia	Aberdeen	Stornoway	Castletown	Time
January	26	26	26	24	28	27	27	16	20	19	30	16	13	18
February	35	35	37	29	33	31	28	18	21	28	29	27	22	29
March	46	43	45	38	41	38	34	34	35	36	30	34	34	37
April	43	47	42	36	42	41	38	30	33	36	33	39	42	48
May	48	46	46	41	41	48	38	36	39	42	31	40	41	50
June	52	49	49	46	47	44	40	41	42	37	36	36	36	45
July	50	45	47	41	42	35	30	39	40	26	28	24	34	30
August	53	48	49	44	44	38	33	44	43	26	31	31	31	36
September	46	46	47	44	45	41	35	39	39	36	33	27	31	33
October	40	41	40	36	38	37	38	30	32	28	34	26	27	29
November	29	31	29	26	29	27	30	17	21	25	31	24	21	24
December	26	25	26	21	22	20	22	14	19	17	23	15	14	18
Year	44	42	42	37	39	37	34	32	34	32	31	30	32	36
35 year normal	43	42	42	40	40	39	36	35	35	35	34	30	—	—

Maximum values are indicated by heavy type.

they, like Tiree, are in the Hebrides; the Stornoway record was available over the period 1927-1932 and that for Castlebay over the period 1908-1926. We see that in April and May Tiree had the largest average daily value and that in June only at Eastbourne, Brighton and Seilly was the Tiree figure exceeded. Even in March we note that the Tiree average was greater than that for any of the Irish or Scottish stations quoted in the table and also greater than that for either Kew or Greenwich. The mean daily figures for the year portray the same characteristics as those for March. The excess of the daily average for the year at Tiree over that for Kew, Greenwich, Valentia, Dublin and Aberdeen is in each case quite appreciable and, indeed, rather surprising in its amount in the cases of Kew, Greenwich and Valentia; Tiree's excess over Castlebay and Stornoway is perhaps somewhat greater than might have been anticipated.

We have in Table II expressed the figures, given in Table I, as a percentage of the mean length of the day at each station, allowance being made for the period when the sun has an elevation of 3 degrees or less above the horizon; no other allowances for obstructions were made. Here again we see that during April and May the greatest percentage of possible sunshine was registered at Tiree; in April the percentage at Seilly closely approximated to that for Tiree, while in May the nearest was Eastbourne, which was closely followed by Douglas. Table II brings out another important feature, namely, that May at Tiree, Douglas, Valentia and Stornoway had the greatest monthly percentage of possible sunshine, while at the remaining stations, with the exception of Castlebay, the greatest percentage occurred in either June or August, this seeming to indicate that in extreme western districts the month registering the greatest percentage of possible sunshine is May. Returning to Table I, we note, however, that only at Tiree, Castlebay, Stornoway and Valentia was the daily sunshine duration actually greatest in May; at the remaining stations the largest average daily figures were registered in June, there being little difference between the May and June figures for Douglas.

At the bottom of Table II the normal daily sunshine for the year for the standard period 1881-1915 is expressed as a percentage similar to that for the period 1927-1932. We note that the percentages for the two periods, 1881-1915 and 1927-1932, are in very good agreement, the latter period being slightly the less sunny of the two, so that we may assume that the period 1927-1932 was not in any way exceptional as regards the distribution of sunshine. The setting up of a sunshine recorder at Tiree has thus probably enabled us to locate the sunniest region in the British Isles during the months of April and May—and that a somewhat unexpected region.

## OFFICIAL PUBLICATION

The following publication has recently been issued.  
PROFESSIONAL NOTES.

No. 64. *The vertical extent of north-westerly winds over Iraq in summer.* By S. P. Peters, B.Sc. (M.O. 336d.)

The north-westerly winds, which occur almost continuously in Iraq during the months June to September, are frequently of such strength as to constitute a serious hindrance to aircraft engaged in making a return passage from India to Egypt. Hence it is a matter of practical interest and importance to know that frequently these winds do not extend above about 7,000 feet, a marked change in speed and direction being experienced above that height, and that in some cases this change takes the form of a complete reversal of direction from north-westerly in the lower layers to south-easterly above.

## Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, April 26th, in the Society's Rooms, at 49, Cromwell Road, South Kensington, Prof. S. Chapman, F.R.S., President, in the Chair.  
C. S. Durst, B.A.—*The intrusion of air into anticyclones.*

An examination of the dynamical equations of rotating fluid on a rotating globe shows that the descent of air in an anticyclone will cause an inflow towards the centre of the right order of magnitude to balance the outflow of air due to friction near the surface. An explanation is given of the empirical forecasting rule that warm-core anticyclones are likely to endure.  
H. M. Vernon, M.A., M.D.—*The estimation of solar radiation in relation to its warming effect on the human body.*

The globe thermometers described consist of globes of copper, glass or pastboard, painted black or covered with cloth, and with an ordinary thermometer fixed so as to have its bulb in the centre. Up to a certain point the larger the size of such globes the higher the temperature indicated on exposure to solar radiation, but the limit is practically reached with globes 6 to 9 inches in diameter. The temperature then indicated corresponds with the warming effect of the solar radiation on the human body, as was proved by indoor tests on artificial radiant heat as well as by outdoor tests on solar radiation.

Globe thermometers are considerably influenced by wind velocity. For instance, a light breeze (eight miles an hour) reduced the globe temperature—in excess of air temperature—to 44 per cent. of its excess in nearly calm air, whilst it reduced the excess temperature of a clear glass solar radiation thermometer (black bulb in vacuo) only 7 per cent.

J. Glasspoole, Ph.D.—*The rainfall over the British Isles of each of the eleven decades during the period 1820 to 1920.*

It is obviously desirable to review, from time to time, the

rainfall recorded during recent years, in comparison with that experienced during as long a period as possible. Maps are given showing the rainfall experienced over the British Isles during each of the eleven decades, 1820-29 to 1920-29. The rainfall of each locality is given as a percentage of that for the standard period 1881 to 1915, so that each map presents a fairly simple distribution. The main feature of the distribution of rainfall during the decade 1920-29 was that excesses were most marked in the west of Great Britain, while during the decade 1910-19 (covering the war years) the excesses were most marked in the south of England.

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## Correspondence

To the Editor, *The Meteorological Magazine*.

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### Summer Thunderstorms

In his very interesting and suggestive article on "Summer Thunderstorms," Captain Douglas refers to the "misleading notion that thermal instability is developed between a warm south-east current and an over-running colder south-west current, even at considerable heights." The first time the "notion" came to my knowledge was in France during the War, when Major Goldie drew attention to the fact which he had noted in the Somme area, viz., that there was a tendency for thunderstorms to develop with a wind at 4,000 or 5,000 feet from a south-westerly direction over a surface wind from a southerly or south-easterly direction.

Captain Douglas advances, as a reason against the "notion," the fact that in a layer in which the gradient wind veers with increasing height, the horizontal transport of air is from warm to cold; and this temperature factor would indeed be a "complete preventive" of thunderstorms with a veering upper gradient wind, if the gradient wind went on veering right up to the stratosphere; but the factor ceases to be effective when the veering ceases. The upper wind may then be transporting relatively cold air, instead of relatively warm air, across the surface isobars (from low to high). It is practically certain that in individual cases this does happen, and if the surface air has been warmed substantially as continental air may be warmed substantially in summer, then there may also be instability.

I think statistical investigations are extremely useful, especially to give some indication of the weight to be attached to any empirical rule. While I am satisfied from Captain Douglas's results that the suggestion "that a south-west wind at 5,000 feet over a south-east surface wind is favourable to thunderstorms" must be used with a good deal of caution, and taken in conjunction with other factors, I do not feel convinced

that his statistical investigation has proved that the factor is of no use. (Why even to-day there was a veering upper wind over an easterly surface wind in front of thunderstorms.)

As I mentioned above, if a cold south-west upper wind over a warmer lower current from south-east or south is a source of instability and thunderstorms, then the wind certainly cannot go on veering with height indefinitely, and Captain Douglas's earlier remark, that a veer above 10,000 feet was unfavourable for thunderstorms, is quite in accordance with this view. Thus a condition, which must be necessary in addition to the veer in the lower levels, is a cessation of the veer or a backing at higher levels. It would be interesting to know what was the character of the curve showing the relation between wind direction and height for those cases of a veering wind which gave thunderstorms and for similar cases which did not.

Some thunderstorms appear to be due to diurnal heating of air more or less *in situ*. Those which are not will usually be due either to the intrusion of warm air beneath cold air, or to the over-running of cold air over warm air. In north-east France in summer, that usually meant a wind veering with height. The veer may not have been as much as  $90^\circ$ ; a smaller veer would be sufficient. It is quite likely that southern England is different from north-east France in this respect, because the Channel and the North Sea are not meteorologically insignificant.

A further factor which cannot be neglected in a consideration of thunderstorm problems is humidity. No amount of cold upper air can produce a thunderstorm if the air is dry, nor can diurnal heating.

The main point, in my view, in support of the idea that a veer of the wind at 4,000 or 5,000 feet from the surface isobars is a factor in connexion with the thunderstorm question, is that such a veer indicates an appreciable horizontal gradient of temperature; (so, of course, does a backing): a horizontal gradient of temperature is almost an essential for instability: thus, if there is such a veer up to 4,000 or 5,000 feet, one of the essentials for instability is present—and thunderstorms are instability phenomena.

E. GOLD.

8, Hurst Close, London, N.W.11. May 3rd, 1933.

In my article in the April number of this *Magazine*, there is an accidental omission near the middle of p. 59, where it should have been stated that the computation was based on a gradient wind of 10 metres per second and an angle of  $20^\circ$  between the surface wind and the isobars. In the sentence at the foot of p. 56, there is a possibility of some misunderstanding due to over-condensation, but it is fairly obvious from the context that the 156 cases represent the sum of the south-west and south-east upper currents, and that cases with northerly components at high levels were not considered. The latter are fairly

numerous in anticyclones. South-east winds at high levels are rare in anticyclones, but it must be remembered that days with no high or medium clouds are automatically excluded from consideration unless a pilot balloon is followed to a sufficient height. Nevertheless I think the evidence is sufficient to show that south-easterly winds at high levels are normally associated with shallow depressions or troughs, or the intermediate regions between anticyclones and depressions, and that they are very favourable for thunderstorms. Many of the storms are of diurnal convectional type and affect the Midlands rather than the extreme south-east, but late in the day continental storms sometimes cross the Straits of Dover.

C. K. M. DOUGLAS.

April 26th, 1933.

### A Thunderstorm Phenomenon

Observations have occasionally been recorded in this publication of a sharp "vit" or "click" accompanying lightning flashes. It has been described as occurring simultaneously with the lightning and preceding the thunder. The undersigned is collecting records of such occurrences, and would be glad to receive from readers, especially those connected with the Thunderstorm Census Organization, details such as the following:—

- (1) Approximate distance of the lightning flash.
- (2) Direction of the "vit" with respect to that of the lightning.
- (3) Number of people who observed simultaneously the "vit."
- (4) Whether only the most severe flashes were accompanied by the "vit."
- (5) Whether observed indoors or in the open.

S. E. ASHMORE.

22, Soho Road, Handsworth, Birmingham, 21. April 30th, 1933.

### Spells of Sunshine

In the April number of this *Magazine* Mr. Dunbar raises the question of classifying sunshine records under headings such as "sunny period," "dull period," etc., and tentatively suggests certain definitions. As opinions are invited, I venture to offer the following remarks:—

In the first place, when one sets out to invent a term to which a precise meaning is to be ascribed, it is very desirable to avoid words or expressions which are in daily use. From this point of view I would suggest that it is preferable to use the word "spell" rather than "period." The term "sunny spell" is not so likely to be employed in general descriptions of sequences of weather as the term "sunny period," and is, therefore, in my submission, a more appropriate term to use



in a specialised sense. Perhaps Mr. Dunbar will agree, therefore, to allow me to speak of "sunny spells," "bright spells," "dull spells" and "sunless spells" in the subsequent discussion.

To see how Mr. Dunbar's proposals would work out I looked through the Kew Observatory records for 1931, with the following results:—

*Sunny Spells* (30 successive days with recordable sunshine).  
Nil.

*Bright Spells* (15 successive days with 1 hour or more of sunshine).

March 7th—23rd = 17 days.

May 24th—June 8th = 20 days.

June 25th—July 14th = 20 days.

*Dull Spells* (15 successive days not having 1 hour or more of sunshine).

Dec. 11th—26th = 17 days.

*Sunless Spells* (10 successive days with no recordable sunshine).

Dec. 11th—25th = 16 days.

1931 was a dull year in south-east England. At Kew sunshine was substantially below normal in every month from April to September. I find, however, that from February 1st to November 30th there were only 42 days without sunshine. Of the 261 days in that period with some sunshine, only 49 had less than one hour. In the summer months June, July and August (in each of which sunshine was very deficient) there were only 16 days with less than one hour of sunshine, and only five with none at all. Except for breaks of single days on June 10th, June 24th, July 15th, August 14th and August 24th, the entire period from May 18th to September 4th would have been a "sunny spell" as defined by Mr. Dunbar. As it turned out, however, there was no spell quite reaching 30 days without interruption. There were, however, no fewer than three "bright spells." My general impression is that in framing definitions of the kind required one would have to take account of the following facts:—

1. Days with less than one hour of sunshine are infrequent in the summer.
  2. Spells of as many as fifteen days each with less than one hour of sunshine are practically confined to the winter months.
  3. Spells of fifteen or more days each with one hour or more of sunshine are too frequent to call for special comment.
- (These remarks apply to all except the least sunny districts of the British Isles.)

In view of the large seasonal variation of sunshine, I very much doubt the possibility of framing really satisfactory definitions. To cut out all but the really noteworthy sequences in summer, I think it would be necessary to raise the limit for :

"bright spell" from one hour to three hours, but that would be too high a limit for the winter months. Possibly the best course would be to make the criterion "one-fourth of the possible mean daily duration," both for "bright spells" and "dull spells," leaving the definitions as they stand in other respects.

E. G. BILHAM.

April 28th, 1933.

### Halo System seen from Hastings

I beg to submit some notes on a halo system which was observed here on April 14th last. The phenomenon was by no means an unusual one and did not rival that seen here on December 19th, 1932, but is of interest from the fact that the sky appeared to be absolutely free from cloud in its vicinity though a little cirrus lay to the south. This cloud had moved from due north and, when passing over the sun some time previously, did not produce even a trace of a halo. The sky did not present even the milky appearance produced by the lofty cirro-nebula, but was of the clear blue often seen on those days with settled weather and a dry easterly wind. A little fracto-cumulus was seen inland.

At 12h. 5m. G.M.T. the system consisted of an upper and lower portion of the ordinary halo, both brightly coloured and the upper having the circumscribed arc of contact. To the south-east a coloured arc of the 46° halo was seen, while the white parhelic circle extended from the ordinary halo round by east to about north-east and was most pronounced nearest the halo. The circle did not pass through the sun as I observed on a previous occasion. The phenomenon gradually faded. The above may have been due to fine ice dust, and it is worthy of note that some of the most perfect haloes seem to occur in the thinnest of high cloud, especially cirro-nebula.

A. E. MOON.

89, Olive Avenue, Clive Vale, Hastings. April 18th, 1933.

### Local Fog

It was interesting on the morning of March 3rd, 1933, during the period when persistent fog over the snowbound area of north Yorkshire held up for several days aerial communication between England and Scotland, to observe near Cranwell an illuminating example of the effectiveness of snow in producing local fog.

The air was moist after continuous light rain during the night, and there had been mist earlier; but at the time of observation (8h. 20m.) visibility was about 6 miles generally. The humidity measured immediately afterwards at the Meteorological Office a mile away was 97 per cent and the temperature 49°F. A south-easterly wind of 12 m.p.h. was blowing across the heath, and the sky was overcast with alto-stratus and sand.

Small patches of snow still persisted here and there. Over

one of these, measuring about 15 yards by 5 yards, and lying in the lee of a small plantation, a patch of fog was seen. The fog extended upwards from the snow to a height of about six feet in the slowly eddying and drifting air of this sheltered spot, and in the air drifting away it dissolved four or five yards beyond the edge of the snow.

The observation suggests that, given facilities, it would not be impossible to bring into the laboratory the study of advection fog formed in free air.

W. A. HARWOOD.

*R.A.F. Station, Cranwell, Lincs. April 13th, 1933.*

### **Snowdrifts in Warwickshire**

Whilst staying at Chipping Norton over Easter I was informed that, on the exposed ridge, about 700 feet high, which forms an outlying spur of the Cotswolds along the border of Oxfordshire and Warwickshire, and contains the prehistoric stone circle of Rollright above the village of Long Compton, the drifting during the blizzard of February was so severe that a couple of cottages within a few hundred yards of the Rollright Stones were snowed up to bedroom windows. Since this district was well removed from the zone of greatest intensity of the blizzard, I think it is an instructive illustration of the influence of fairly high ground in extending the area of heavy snow. This is confirmed by conditions in the Chilterns, for at Whipsnade on the Dunstable Downs the depth of undrifted snow appears to have been about 2 feet as compared with London's 2 inches only some 40 miles away.

L. C. W. BONACINA.

*85, Parliament Hill, London, N.W.3. April 27th, 1933.*

### **NOTES AND QUERIES**

#### **International Photography of the State of the Sky**

As part of the programme of the second International Polar Year, at present in progress, the International Commission for the Study of Clouds, organised a special "International Cloud Year" for the study of the state of the sky and its variations. In connexion with this investigation General Delcambre, President of the Commission, selected two periods for the special study of clouds in great detail, in France and neighbouring countries. The first of these was April 12th and 13th, and the second is arranged for July 12th and 13th, 1933, and to help in extending the latter beyond the borders of France, General Delcambre has appealed for the assistance of all photographers, whether professional or amateur, who are interested in meteorology.

At least three photographs should be taken each day, as near

as possible to the hours of 8 a.m., 2 p.m. and 7 p.m. Summer Time, and additional photographs at intermediate hours are desirable whenever the general character of the sky changes. The purpose of the photographs is to represent, without any serious gap, the evolution of the cloud systems regarded as a whole. For example, in the course of a fine calm summer day, isolated cumulus clouds form, with growing white "cauliflower" heads. Each isolated cloud is constantly changing, but the evolution of the sky as a whole is much slower, and three photographs during the day would suffice to follow it completely: one taken at the moment when the fine weather clouds form, the second generally in the afternoon when they are most numerous and have reached their full development, and the third in the evening when they are degrading and tend to disappear.

The photographs are for scientific purposes, and their artistic value is a secondary consideration. Groups of clouds should be photographed rather than individual clouds, and if choice is available a wide-angle lens should be employed. If the clouds are thin, a yellow filter should be used to distinguish them from the blue of the sky; on the other hand, if the clouds have heavy shadows, it may be necessary to use a light blue filter to introduce sufficient contrast with the clear sky. The prints should be made to show as much detail as possible, but must not be retouched.

It is essential that on the back of each print should be written the name and address of the photographer, the place where taken, date and time. The following additional information would be of value: amount of sky covered, description of the part of the sky not included in the photograph, direction in which the camera was pointing, and approximate elevation above the horizon. Prints, suitably packed, should be addressed to M. le Ministre de l'Air, Office National Météorologique, 196 rue de l'Université, Paris 7, and in the corner should be written "Année des Nuages."

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### On Readings of a 4-ft. Earth Thermometer in vulcanite and iron Tubes

In the *Meteorological Magazine* for February, 1932, on page 13 there is a note on a comparison between readings of two 4-ft. earth thermometers. These were the Angstrom-Petri thermometer, designed for use in a vulcanite tube, and the Symons thermometer, with its paraffin lagging and large iron tube. It was mentioned in the article that the result of the comparison, which had extended over a year, was that the difference between the readings of thermometers of the two types was quite negligible for any practical purpose. Any regular law obeyed by the temperatures in the two tubes was likely to be masked

by the effects of small errors in the calibration of thermometers.

Accordingly it was decided to use one thermometer on alternate days in the two tubes. In the following table the differences are set out between the means obtained from the readings in one tube or the other at 9h. and at 13h. The routine of alter-

Average readings of the thermometer in the vulcanite tube <i>minus</i> average readings in the iron tube.					
Month.	9h.	13h.	Month.	9h.	13h.
	°F	°F		°F	°F
October ...	+ '10	+ '20	April ...	+ '10	- '01
November ...	+ '23	- '14	May ...	+ '42	- '31
December ...	+ '23	+ '08	June ...	- '21	+ '35
January ...	+ '11	+ '12	July ...	- '08	+ '00
February ...	+ '14	+ '08	August ...	+ '05	- '12
March ...	+ '17	'00	September ...	- '07	+ '09
Means...	+ '17	+ '07		+ '035	+ '01
Means for 12 months				+ '10	+ '04
Mean for all readings + '07° F					

nate observations in the two tubes was usually interrupted on Sundays, but the thermometer spent as many days in one tube as in the other.

It will be noticed that on the average the vulcanite tube gave the higher readings during the winter months, the season of falling temperature at 4 feet; fluctuations in the computed means for the summer months, the season of rising temperature, are quite irregular and may be attributed to the fact that the temperatures were not taken on the same days in the two tubes.

The general average for the difference in temperature in the two tubes is .07° F., the vulcanite tube yielding the higher readings. The explanation may be that in winter cold air falls down the large iron tube to mix with the air at 4 feet. In summer at 13h. the stratification in the iron tube is stable and the iron and vulcanite give consistent readings. The 13h. observation in winter and the 9h. observation in summer are intermediate in character. According to this explanation the defect of the Symons thermometer is the use of a large tube, not the use of an iron tube. The introduction of the tube with the smaller bore seems to be a real, though very slight, improvement.

F. J. W. WHIPPLE.

### The "Greenhouse Effect"

Prof. R. W. Wood published many years ago\* a paper in which it was shown that the theory generally advanced to explain the high temperature reached inside a greenhouse in sunny weather is erroneous. Although the matter is of obvious interest for meteorology, it is doubtful whether many meteorologists are aware of the existence of this paper, and a brief summary of it may, therefore, not be out of place. In Prof. Wood's own words "there appears to be a widespread belief that the comparatively high temperature produced within a closed space covered with glass, and exposed to solar radiation, results from a transformation of wave-length, that is, that the heat waves from the sun, which are able to penetrate the glass, fall upon the walls of the enclosure and raise its temperature: the heat energy is re-emitted by the walls in the form of much longer waves, which are unable to penetrate the glass, the greenhouse acting as a radiation trap. I have always felt some doubt as to whether this action played any very large part in the elevation of temperature. It appeared much more probable that the part played by the glass was the prevention of the escape of the warm air heated by the ground within the enclosure."

To test this view Prof. Wood constructed two enclosures of black cardboard, one covered with a glass plate, the other with a plate of rock-salt of the same thickness. On exposing these to the sun, and placing a thermometer in each, it was observed that the reading of the thermometer under the rock-salt rose slightly faster than that of the thermometer under glass, a result which he attributed to the fact that practically all the wave-lengths in the solar radiation passed through the rock-salt, but only the short wave-lengths through the glass. To eliminate this the sunlight was first passed through a glass plate so that those long waves that were unable to pass through the glass did not fall upon either enclosure, and the amount of radiation received was practically the same in each case. It was found that there was then a difference of temperature of less than a degree centigrade between the two, the maximum reached being about 55°C. He concludes from this that the loss of temperature from the ground by radiation is very small in comparison with the loss by convection, and that the action of the greenhouse depends almost entirely upon the elimination of convectional loss. A small point worth noting is that the word convection is used to describe a process of replacement of warmed by unwarmed air, which in windy weather might be caused largely by turbulence due to obstruction of the wind by obstacles and to friction between the moving air and the stationary ground, but this does not affect the important conclusion that trapping

\*See *Phil. Mag.* London 17, 1900, p. 310.

of radiation plays a negligible part in the so-called "greenhouse effect."

### Measurement of Evaporation

The measurement of evaporation has not received so much attention by meteorologists as some other meteorological factors, partly, no doubt, because the rate of evaporation from a water surface, in this country at least, is so small that an instrument of considerable precision is needed to measure it accurately and such instruments are not always well adapted for use at meteorological stations, but chiefly because the readings of evaporimeters do not necessarily accord with the loss by evaporation from a large water surface, such as a river, lake or ocean, or with the loss from damp ground, the evaporation which is of practical importance in meteorology. The subject is, however, of considerable interest and we welcome a paper "On Evaporation and its Measurement," by Dr. S. K. Banerji and Mr. H. M. Wadia, which has recently appeared among the Memoirs of the Indian Meteorological Department. This paper describes work done at Bombay Observatory both with an evaporation tank in the open and with a small tank used for laboratory experiments.

For the outdoor experiments a tank measuring 4 by 3 by  $2\frac{1}{2}$  feet was used, this being surrounded by a channel  $7\frac{1}{2}$  inches wide, which was also filled with water to diminish the "edge effect" in the tank proper. It was desired to obtain a continuous record of the loss of water by evaporation, and much thought was given to the recording mechanism in order to avoid unnecessary friction and errors due to capillarity and change of temperature. In the method adopted, a glass float was protected by a fixed cylindrical casing placed in the tank, the water connexion being made by means of a hole near the bottom of the casing. The movement of the float was recorded on a smoked sheet by means of a simple lever giving a magnification in one instrument of 21 to 1 and in another of 14 to 1. It was found that with a float 14 cm. in diameter a record free from frictional effects could be obtained and the authors are of opinion that previous workers in this field have erred by the use of too small a float. The expansion and contraction of the water in the tank with change of temperature naturally led to some disturbance in the record, but calculation showed that the error introduced into any individual hourly reading might be neglected as the change in volume between the hour of minimum water temperature in the morning and that of maximum temperature in the afternoon was less than 7 per cent of the loss by evaporation over the same period and the readings cannot attain to this degree of accuracy. The steady movement of the float was dis-

\* Calcutta, Ind. Meteor. Dept. Memoirs Vol. xxv, Part 1a.

turbed by the action of ripples on the water surface, so that on all occasions when there was wind the pointer gave a record somewhat resembling that of a pressure tube anemometer. In these cases a middle line through the ribbon trace was used for the determination of evaporation. This "gustiness" of the trace was regarded by the authors as being advantageous since the movements showed directly the size of the ripples and, therefore, the strength of the wind blowing over the water surface. It is clearly this wind which is effective in accelerating the rate of evaporation rather than the wind measured by an anemometer at a considerable height above the ground and at some distance away and, therefore, for purposes of correlating evaporation with the strength of the wind, the "gustiness" of the trace is useful.

After discussing the several sources of error the authors proceed to a consideration of the records obtained. The two recorders were both used in the same tank and the water level read off at hourly intervals throughout the day. Evaporation for each hour was thus obtained. The two records were not in entire agreement for the individual hours, differences amounting to 50 per cent or more being occasionally met with. Over a longer period, such as a whole day, however, the records were in good agreement and there can be little doubt that the readings were sufficiently accurate to show both the changes in the evaporation from day to day and the trend of the rate of evaporation through the 24 hours.

Measurements were made both with fresh water and sea water in the tank, though a single tank only being available, it was not possible to obtain simultaneous measurements to compare the two rates of evaporation. No attempt was made to measure the evaporation on days of rainfall. The mean rate of evaporation from fresh water over 30 days in April and May, 1930, for which satisfactory records were obtained with one recorder, was 0.25 mm. per hour, the average daily maximum rate of 0.47 mm. per hour occurring just before 5 p.m. and the average minimum rate of 0.09 mm. per hour occurring between 7 and 8 o'clock in the morning. The mean rate of evaporation from sea water on 5 days on which measurements were taken amounted to 0.32 mm. per hour. As has already been pointed out, owing to the different weather conditions prevailing, no direct comparison between this figure and the figure for fresh water is possible.

The records obtained do not throw much light upon the effect which the individual meteorological elements, wind velocity, air temperature and relative humidity, have on evaporation, owing to the close inter-relation of the variations of these elements throughout the 24 hours at Bombay. Thus, in the afternoon, temperature and wind velocity reach their maximum values and



the relative humidity its minimum value, each factor playing its part in increasing the rate of evaporation. It is noteworthy that in this part of their work, the authors have paid little attention to the temperature of the water in the evaporation tank. There is little doubt that this is a factor which affects the rate of evaporation to a marked degree, and it is partly because the temperature of the water in an evaporation tank may differ so widely from that of natural waters that the readings of evaporation tanks are believed by many meteorologists to bear little relation to the actual rate of evaporation from a natural sheet of water.

The laboratory experiments, which were made in a somewhat smaller tank, were taken in hand with a view to determining the effect of the different meteorological elements on evaporation and these are discussed in the second part of the paper. Arrangements were made to blow a stream of air over the tank by an electric fan and also to apply artificial heat by electric radiators. The strength of the air current and the supply of heat could both be varied. The conclusion reached was that evaporation varies as the square root of the wind velocity except at very low speeds, a conclusion which is in agreement with some theoretical work of Jeffreys published in 1918. Certain other conclusions reached by Jeffreys regarding the effect of tanks of different sizes and shapes were also confirmed. The laboratory tests on the effect of varying temperature were less satisfactory owing to the fact that no attempt seems to have been made to vary the temperature of the water and the air independently. The electric radiators heated both air and water and the curves given in the paper show that the rate of evaporation increased with increasing temperature as would be expected, but do not permit any separation of the effects of air and water temperature. Jeffreys's formula for evaporation contains  $K$ , the co-efficient of eddy diffusion, and an attempt has been made by the authors of the present paper to determine the value of  $K$  by this means.

Another paper on the theoretical aspects is promised by Dr. Banerji later, and it may be hoped that in this an attempt will be made to elucidate the effect of water temperature in more detail. The hope may also be expressed that when the authors have obtained further observations in the field covering a complete period of 12 months or more, they will again publish the readings. The apparatus which has been evolved is of sufficient precision to justify the discussion of a more extensive series of observations than those which are recorded in the present paper.

J. S. DINES.

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**Congress of the Royal Institute of Public Health at  
Eastbourne, May 30th to June 4th, 1933**

The annual congress of the Royal Institute of Public Health will

be held in Eastbourne from Tuesday, May 30th, to Whit-Sunday, June 4th, under the presidency of the Right Hon. the Viscount Leverhulme. In addition to the usual purely medical sections, a section on Hydrology and Climatology will be included for the first time, the President of this section being Professor Sir Gilbert T. Walker, while the Vice-Presidents include Dr. G. C. Simpson and Dr. F. J. W. Whipple.

The Presidential Address to this section will be on "Airs, waters and places, their importance in medicine," and the following papers will also be read:—

"Records of humidity and what they teach us about the atmosphere outside and indoors," by Dr. F. J. W. Whipple.

"The effect on climatic factors of the nature of soil and of soil drainage," by D. Brunt.

"Soil and climate in relation to the rheumatic diseases," by Dr. E. C. Warner.

"Sea bathing: some medical aspects of a complete scheme," by Dr. G. R. Bruce.

"Smoke pollution of the atmosphere," by Dr. J. S. Owens.

"Health and holidays," by Dr. Robert Marshall.

"The medical profession and the health resort," by Col. R. H. Elliott.

"The sea breeze as a climatic factor," by E. G. Bilham.

"Medical indications for the sea coast," by Dr. N. E. Chadwick.

The programme also includes visits to hospitals and other institutions, a banquet and various evening receptions. Membership of the Congress is open, the fee being one guinea. The membership ticket and full particulars will be forwarded on application to the Secretary, Royal Institute of Public Health, 23, Queen Square, London, W.C.1.

### **The Halley Stewart Laboratory**

In *The Times* of May 5th appears an interesting announcement of the opening of the new Halley Stewart Laboratory at 30, Chesterford Gardens, Hampstead. In this laboratory will be carried on Professor Appleton's researches into the electrical properties of the upper atmosphere, the researches which were previously carried on in the laboratories of King's College having suffered from the disturbances set up by local electrical machinery.

The formal opening was performed by Lord Rutherford, who in his speech alluded to the remarkable progress which has been achieved in recent years by the use of electric waves in the exploration of the upper atmosphere. The methods introduced by Professor Appleton led to the discovery of a second ionised layer at a greater height than the layer of which the existence

was inferred many years ago by Balfour Stewart and other investigators and which is usually called the Kennelly-Heaviside layer. This second layer is known as the Appleton layer, in honour of its discoverer. The problems of the propagation of radio signals are of great practical importance, and the new laboratory will provide opportunities for carrying on valuable research work.

S. T. A. MURRELLS.

### Films on our Book-shelves

An unusual addition has recently been made to the Meteorological Office library in the form of a small tin containing a tiny roll of film about  $1\frac{1}{8}$  in. in height and  $1\frac{1}{4}$  in. in diameter. Apart from a few pages of printed text and three diagrams, this roll constitutes the *Jahrbuch des Meteorologischen Observatoriums auf dem Donnersberge (Böhmen) für 1929*.

In an article which appeared in the previous issue of this year-book, Dr. L. W. Pollak discussed at some length the question of reproducing meteorological year-books on cinema films. Taking the 1927 year-book as a basis for calculation, he showed that the tabular part could thus be reproduced at less than half the usual cost by lithographic process while if the original manuscript tables instead of typescript copies were used the costs would be reduced by more than three-quarters. A further economy would be effected in postage, especially in the case of copies sent to foreign countries. In addition to these financial advantages, Dr. Pollak stressed the value of "filmed" year-books as a means of saving space. Any one who has been confronted with the problem of housing indefinitely within a strictly limited space the ever-increasing masses of statistical data, etc., will realise the attraction of any promising means of economy in this respect. According to calculations published in Germany a roll of film scarcely requires one-fortieth of the space occupied by a corresponding book. There is also a similar reduction in weight. A further advantage would be that additional copies of the whole or any part of the film could be made from the original negative as and when required at no higher rate of expense and therefore it would be unnecessary in the first instance to prepare more copies than were actually needed for distribution.

The speedy adoption of this method of publication by the Geophysikalisches Institut der Deutschen Universität in Prague was due in part to the unavoidable necessity of covering expenses out of reduced funds as stated in the introduction to the 1929 year-book. This introduction also contains an important note to the effect that it can be used without risk of fire as the copies have been made on non-inflammable Agfa films.

Against the advantages to which Dr. Pollak draws attention,

certain obvious disadvantages must be off-set, such as the necessity of providing film reading or projecting apparatus. It may perhaps be possible to read the tables with no further equipment beyond a powerful magnifying glass, but the time taken in unrolling a little reel several yards long, containing hundreds of tables which may have to be scrutinised in search of the one required would seem very long compared with that used in turning to a given page in a book. In an institution where very frequent reference is made to the tables the usual style of reproduction in book form would seem desirable and it is understood that a typescript copy has been provided for the "Staatsanstalt für Meteorologie" in Prague.

The ingenuity displayed in this experiment calls forth admiration. It remains for time to show how far the fashion will spread.

### Books Received

*Anales del Observatorio Nacional de San Bartolomé en los Andes Colombianos. Observaciones meteorológicas de 1929.* Bogotá, 1931.

*The lunar atmospheric tide at Bombay (1873-1922)*, by S. K. Pramanik, M.Sc. *Memoirs of the Indian Meteor. Dept.*, vol. xxv, Part viii. Calcutta, 1931.

### The Weather of April, 1933

Pressure was below normal over Russia, western Siberia, most of Scandinavia, most of the North Atlantic, the United States and the part of Canada between the Great Lakes and Hudson Bay, the greatest deficits being 6.6 mb. at Moscow, 7.0 mb. at 50°N., 30°W., and 4.3 mb. at 40°N. 90°W. Pressure was above normal elsewhere in Canada and over Bermuda, Newfoundland, Greenland, Spitsbergen, Iceland and western, central and southern Europe, including south Scandinavia and the Balkan States, the greatest excesses being 7.8 mb. at Julianehaab and 5.7 mb. at London and Scilly. In Sweden temperature was unusually normal, the greatest deficit being about 4°F. in northernmost Lapland, while rainfall was mostly about half the normal amount or less, with the exception of Gothaland and northern Lapland. In north-western Gothaland only about  $\frac{1}{4}$  of the normal amount occurred.

Mainly anticyclonic conditions prevailed over the British Isles during April, with rainfall and sunshine (except in the Midlands) generally deficient over the whole country and temperature above normal. Absolute droughts beginning on the 1st were experienced at numerous places in the Midlands—in some cases the drought lasted to the 22nd inclusive. From the 1st to 10th the southern half of the country was covered by an anticyclone, which from the 4th to 7th extended over the whole country, but

depressions moving north-eastwards to the north of the country and low pressure to the east brought slight rain locally in the north and west on several days, with heavy rain in Scotland and north-west England on the 2nd and 8th, and snow or sleet showers in north-east Scotland on the 1st; 6.50 in. of rain fell at Dunhaddale, Loch Carron, Ross-shire, and 4.14 in. at Kinlochquoich, Inverness-shire, on the 2nd. Over most of England during this time the weather was sunny and warm, the warmest, sunniest day being the 8th, when 73°F. was registered at Greenwich and 71°F. at Tottenham, S. Farnborough, Tunbridge Wells, Dovercourt and London, and 12.3 hrs. bright sunshine occurred at Bath, 12.2 hrs. at Bournemouth, and 12.0 hrs. at Littlehampton. Temperature fell somewhat the following day but rose again over 70°F. in the south-east on the 11th as a depression approached the British Isles; 72°F. was registered at South Farnborough, Shoeburyness and London on the 11th, but sunshine records were small in that area. Slight rain fell locally on the 12th, though sunshine records were good in Scotland, reaching 11.3 hrs. at Dunbar and 11.1 hrs. at Aberdeen. On the 13th the country came again under the influence of an anticyclone and sunny weather prevailed generally, but cold north-westerly winds were experienced in the north and east. A small depression passed to the north of Scotland on the 15th, bringing rain only to the north, but in its rear the cold winds in the north spread southward reaching southern England by the 17th and causing a marked fall in temperature. These cold winds continued until the 22nd with variable amounts of sunshine, though daily values at a number of places exceeded 10 hrs.; St. Ives had 13.0 hrs. on the 16th. Slight rain occurred locally on many days and snow and sleet showers over the country generally on the 19th and 20th. On the 22nd a complex depression approached from the Atlantic and spread gradually across the country, giving mild unsettled conditions with rain at times, heavy locally, but also considerable periods of bright sunshine, 12.3 hrs. at Kirkwall (Orkneys) on the 23rd, and 12.4 hrs. at Pembroke on the 29th and Calshot on the 30th. The rainfall was heaviest in Ireland, where 1.88 in. fell at Fofanny (Co. Down) on the 24th, and 1.38 in. at Dunmanway (Co. Cork) on the 22nd. Thunderstorms were experienced at many places on the 28th, 29th and 30th. The distribution of bright sunshine for the month was as follows:—

	Total	Diff. from normal		Total	Diff. from normal
	(hrs.)	(hrs.)		(hrs.)	(hrs.)
Stornoway	111	—43	Liverpool	146	—12
Aberdeen	113	—45	Ross-on-Wye	164	+14
Dublin	146	—19	Falmouth	162	—22
Birr Castle	120	—25	Gorleston	155	—20
Valentia	112	—43	Kew	176	+18

The special message from Brazil states that the rainfall in the northern and central regions was plentiful with 4.69 in. and 1.02 in. above normal respectively, but generally scarce in the southern regions with 1.18 in. below normal. Four anticyclones passed across the country and frosts were experienced towards the end of the month. The crops were generally in good condition owing to favourable weather. At Rio de Janeiro pressure was 2.8 mb. above normal and temperature 2.7°F. below normal.

*Miscellaneous notes on weather abroad culled from various sources.* On the 6th the river and bar were reported free of ice at Parnu (Gulf of Riga). No rain fell in Switzerland for the first three weeks of the month; water became scarce in some districts and forest fires were numerous. The temperature also was low round about the 20th, when 18°F. was recorded in the lower regions causing much damage to fruit trees in blossom. Snow fell to a level of 3,000 ft. but in small quantities, and the lower Alpine passes were open to motor traffic on the 22nd. (*The Times*, April 6th-22nd.)

Strong winds were reported over the Himalayas during the greater part of the month, but the lulls were of sufficient length to allow the Houston Mount Everest expedition to accomplish their object of flying over the mountain. A hurricane passed over the northern end of the central islands of the New Hebrides on the western Pacific on the 8th and 9th doing serious damage to property and crops. (*The Times*, April 3rd-21st.)

A hurricane struck Bermuda on the morning of the 26th doing much damage. (*The Times*, April 27th.)

The United States naval airship *Akron* crashed into the sea off the New Jersey coast during a severe thunderstorm accompanied by fog on the 4th. After fine weather during the first week of the month, rain fell in the maize areas of the Argentine interfering with picking operations. Dense fog and then a gale at Tristan da Cunha on the 26th and 27th prevented the landing of stores. Temperature was above normal over the United States generally at the beginning of the month, but later cold spells passed across the country from west to east. Rainfall was variable, but mainly above normal in the Atlantic Coast States and below normal in the Mountain Region and along the Pacific coast, though some moderate falls occurred locally at Lander and Cheyenne during the week ending the 25th. (*The Times*, April 8th-29th, and *Washington D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin*)

### General Rainfall for April, 1933

England and Wales	...	70	} per cent of the average 1881-1915.
Scotland	...	95	
Ireland	...	65	
British Isles	...	76	

## Rainfall: April, 1933: England and Wales.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>London</i>	Camden Square .....	·83	54	<i>Leis.</i>	Thornton Reservoir ...	1·32	73
<i>Kent</i>	Tonterden, Ashenden...	1·18	73	"	Belvoir Castle.....	·96	68
"	Folkestone, Boro. San.	1·22	...	<i>Rut.</i>	Ridlington .....	·79	50
"	St. Peter's, Hildersham	...	...	<i>Linca.</i>	Boston, Skirbeck .....	1·22	90
"	Eden' bdg., Falconhurst	·87	80	"	Cranwell Aerodrome ...	1·44	109
"	Sevenoaks, Speldhurst	·82	...	"	Skegness, Marine Gdns	1·00	75
<i>Sus.</i>	Compton, Compton Ho.	1·45	72	"	Louth, Westgate .....	·75	45
"	Patching Farm .....	1·04	59	"	Brigg, Wrawby St. ...	·97	...
"	Eastbourne, Wil. Sq.	1·04	57	<i>Notts.</i>	Worksop, Hoodsok ...	·98	40
"	Heathfield, Barklyo ...	1·31	71	<i>Derby.</i>	Derby, L. M. & S. Rly.	1·27	78
<i>Hants.</i>	Ventnor, Roy. Nat. Hos.	1·78	100	"	Buxton, Terr. Slopes	1·71	58
"	Fordingbridge, Oaklands	1·98	92	<i>Ches.</i>	Runcorn, Weston Pt. ...	·81	47
"	Ovington Rectory .....	1·33	70	<i>Lancs.</i>	Manchester, Whit Pk.	·98	51
"	Sherborne St. John ...	1·15	65	"	Stonyhurst College ...	1·70	63
<i>Herts.</i>	Welwyn Garden City...	·85	...	"	Southport, Hesket Pk	1·48	80
<i>Bucks.</i>	Slough, Upton .....	·99	69	"	Lancaster, Greg Obay.	2·08	93
"	H. Wycombe, Flackwell	1·07	...	<i>Yorks.</i>	Wath-upon-Deane ...	1·41	80
<i>Oxf.</i>	Oxford, Mag. College...	1·13	78	"	Wakefield, Clarence Pk.	1·50	93
<i>Nor.</i>	Pitsford, Sedgemoor...	·59	30	"	Oughtershaw Hall.....	1·80	...
"	Oundle .....	·81	...	"	Wetherby, Ribston H.	1·49	85
<i>Heds.</i>	Woburn, Crawley Mill	1·05	70	"	Hull, Pearson Park ...	1·11	71
<i>Cam.</i>	Cambridge, Bot. Gdns.	1·20	88	"	Holme-on-Spalding ...	1·26	...
<i>Essex.</i>	Chelmsford, County Lab.	·70	69	"	West Witten, Ivy Ho.	1·41	90
"	Lenden Hill House ...	·91	...	"	Felixkirk, Mt. St. John	1·44	80
<i>Suff.</i>	Haughley House.....	·98	...	"	York, Museum (Gdns.)	1·09	68
"	Campsea Ash .....	1·30	118	"	Ploking, Hungate ...	1·94	110
"	Lowestoft Sec. School	·90	65	"	Scarborough .....	·93	60
"	Bury St. Ed., Westley H.	1·10	78	"	Middlesbrough .....	·94	69
<i>Norw.</i>	Walls, Holkham Hall	1·00	76	"	Baldordale, Hury Res.	2·50	103
<i>Wills.</i>	Devizes, Highclere.....	1·54	81	<i>Durh.</i>	Ushaw College .....	1·25	66
"	Calne, Oatloway .....	1·20	69	<i>Nor.</i>	Newcastle, Town Moor	1·21	74
<i>Dor.</i>	Evershot, Melbury Ho.	1·09	72	"	Bollingham, Highgrove	1·47	68
"	Weymouth, Westham ...	1·57	95	"	Lilburn Tower Gdns...	1·59	80
"	Shaftesbury, Abbey Ho.	1·31	92	<i>Cumb.</i>	Carlisle, Scalby Hall	1·55	79
<i>Devon.</i>	Plymouth, The Hoe ...	2·06	130	"	Borrowdale, Seathwaite	5·00	72
"	Holne, Church Pk. Cott.	3·12	86	"	Borrowdale, Moraine...	3·11	...
"	Teignmouth, Den Gdns.	1·78	89	"	Keawlok, High Hill...	1·71	56
"	Oullompton .....	2·10	95	<i>West.</i>	Appleby, Castle Bank	1·20	66
"	Sidmouth, Sidmount...	1·91	90	<i>Mon.</i>	Abergavenny, Larch...	1·05	42
"	Barnstaple, N. Dov. Ath.	1·55	78	<i>Glam.</i>	Ystalyfera, Wern Ho.	3·78	98
"	Dartm'r, Cranmore Pool	4·10	...	"	Cardiff, Ely P. Stn. ...	1·72	68
"	Okehampton, Uplands	1·42	45	"	Treherbert, Tynyvaun	3·42	...
<i>Corn.</i>	Redruth, Trowlrigio ...	2·66	92	<i>Carm.</i>	Carmarthen Friary ...	2·20	80
"	Penzance, Morrab Gdn.	2·72	112	<i>Pemb.</i>	Haverfordwest, School	1·32	60
"	St. Austell, Trevarna...	2·69	95	<i>Card.</i>	Aberystwyth .....	·75	...
<i>Sons.</i>	Chewton Mendip .....	2·09	70	<i>Rad.</i>	Birm. W.W. Tynyynydd	1·18	32
"	Long Ashton .....	1·18	54	<i>Mont.</i>	Lake Vyrnwy.....	1·71	57
"	Street, Millfield.....	1·43	72	<i>Flint.</i>	Sealand Aerodrome ...	·80	58
<i>Glos.</i>	Blockley .....	·86	...	<i>Mor.</i>	Dolgelly, Bontddu ...	·88	24
"	Cirencester, Gwynfa ...	1·28	68	<i>Carn.</i>	Llandudno .....	·62	34
<i>Here.</i>	Ross, Birchloe.....	1·02	54	"	Snowdon, L. Llydaw ...	6·05	...
<i>Salop.</i>	Church Stretton.....	1·00	46	<i>Ang.</i>	Holyhead, Salt Island	·90	43
"	Shifnal, Hutton Grange	1·04	42	"	Llilgy .....	1·38	...
<i>Staffs.</i>	Market Drayt'n, Old Sp.	·80	50	<i>Isle of Man</i>			
<i>Worc.</i>	Ombersley, Holt Look	·80	53	"	Douglas, Boro' Com. ...	2·04	88
<i>War.</i>	Alcester, Ragley Hall.	1·04	62	<i>Guernsey</i>			
"	Birmingham, Edgbaston	·78	42	"	St. Peter P't. Grange Rd	1·32	65

## Rainfall: April, 1933: Scotland and Ireland.

Co.	STATION	In.	Per- cent of Av.	Co.	STATION	In.	Per- cent of Av.
Wigt.	Pt. William, Monreith	1.48	67	Suth.	Melviech	1.50	60
"	New Luce School	2.11	79	"	Loch More, Achfary	7.00	145
Kirk.	Dalry, Glendarroch	2.28	75	Caith.	Wick	1.85	68
"	Carsphairn, Shiel	3.32	81	Ork.	Deerness	2.17	105
Dumf.	Dumfries, Orlinton, R.I.	1.09	76	Shet.	Lerwick	2.22	97
"	Eskdalemuir Obs.	3.04	80	Cork	Caheragh Rectory	3.37	...
Roeb.	Braxholm	1.21	64	"	Dunmanway Rectory	3.24	78
Selk.	Ettrick Maunse	2.25	64	"	Cork, University Coll.	2.58	98
Peeb.	West Linton	2.55	...	"	Ballinacorra	2.12	73
Herw.	Marchmont House	1.62	80	Kerry.	Valentia Obsy	2.92	80
E.Lot.	North Berwick Res.	2.10	150	"	Gearahameon	3.11	54
Midl.	Edinburgh, Roy. Obs.	1.75	119	"	Killarnoy Asylum	...	...
Lan.	Auchtyfardle	1.43	...	"	Darrynane Abbey	2.68	75
Ayr.	Kilmarnock, Kay Pk.	2.82	...	Wat.	Waterford, Gortmore	1.85	74
"	Girvan, Plumore	1.40	50	Tép.	Nonagh, Cns. Lough	1.31	52
Renf.	Glasgow, Queen's Pk.	1.63	78	"	Roscora, Timoney Park	.72	...
"	Greenock, Prospect H.	2.99	82	"	Cashel, Ballinamona	1.41	56
Dute.	Rothcary, Ardonornig.	3.80	...	Lim.	Moynes, Coolnanes	1.23	50
"	Douglas Lodge	2.02	...	"	Castleconnel Rec.	2.00	...
Arg.	Ardgour House	8.70	...	Clare	Inagh, Mount Callan	2.85	...
"	Glen Elvie	10.75	194	"	Broadford, Hurdlest'n.	...	...
"	Oban	8.84	123	Wexf.	Goray, Courtown Ho.	1.47	67
"	Poltalloch	8.12	100	Kilk.	Kilkenny Castle	...	...
"	Inveraray Castle	4.72	103	Wick.	Rathnew, Oloumannon	1.56	...
"	Islay, Ballahna	2.24	78	Carl.	Blackstown Rectory	1.41	58
"	Mull, Bannore	8.50	...	Leix.	Blandsfort House	1.02	39
"	Tirree	3.18	129	"	Mountnellick	1.41	...
Kinr.	Loch Leven Sluice	1.30	68	Offaly.	Birr Castle	.90	46
Porth.	Loch Dhu	1.40	93	Kild'r.	Monasterevin	...	...
"	Balquhiddie, Stronvar	2.70	...	Dublin	Dublin, FitzWm. Sq.	1.02	54
"	Crieff, Strathorn Hyd.	1.52	69	"	Balbriggan, Ardgillan	1.14	58
"	Blair Castle Gardens	1.55	73	Meath.	Beaupara, St. Cloud	1.21	...
Angus.	Kottins School	.84	46	"	Kells, Headfort	1.03	77
"	Pearcie House	2.06	...	W.M.	Monte, Coolatora	1.64	...
"	Montrose, Sunnyside	1.87	75	"	Mullingar, Belvedere	1.50	63
Aber.	Braemar. Bank	1.07	70	Long.	Castle Forbes Gdns.	1.48	62
"	Logie Coldstone Sch.	1.77	88	Gal.	Ballynahinch Castle	2.84	80
"	Aberdeen, King's Coll.	2.07	111	"	Galway, Grammar Sch.	...	...
"	Fyvie Castle	2.85	193	Mayo.	Mallarmy	8.71	...
Moray	Gordon Castle	1.55	80	"	Westport House	1.50	50
"	Grantown-on-Spey	...	...	"	Dolph Lodge	4.68	81
Nairn.	Nairn	2.08	139	Sligo.	Markree Obsy	2.20	87
Inv's.	Ben Alder Lodge	2.69	...	Cavan.	Belturbet, Oliverhill	1.48	62
"	Kingussie, The Birches	2.25	...	Fern.	Emiskillan, Portora	1.24	...
"	Loch Quoich, Loan	3.10	...	Arm.	Armagh Obsy	.85	40
"	Glenquoich	10.60	149	Down.	Fofanny Reservoir	5.02	...
"	Inverness, Oulduthel R.	2.20	...	"	Seaford	2.48	65
"	Arisaig, Fairo-na-Sguir	3.70	...	"	Donaghadee, C. Stn.	1.67	88
"	Fort William, Glasdrum	5.25	...	"	Banbridge, Milltown	.67	38
"	Skye, Dunvogan	4.84	...	Antr.	Belfast, Cavohill Rd.	1.70	...
"	Barrn, Skallary	2.50	...	"	Aldergrove Aerodrome	1.30	62
R & O.	Alness, Ardross Castle	2.60	107	Lon.	Ballymona, Harryville	1.80	68
"	Ullapool	4.85	140	"	Londonderry, Oreggan	1.37	53
"	Achnashellach	0.43	185	Tyr.	Omagh, Edoufcl.	1.97	75
"	Stornoway	12.85	94	Don.	Malin Head	1.55	...
Suth.	Lairg	2.52	103	"	Milford, The Manse	1.53	60
"	Tongue	1.97	75	"	Killybegs, Rockmount	2.00	56

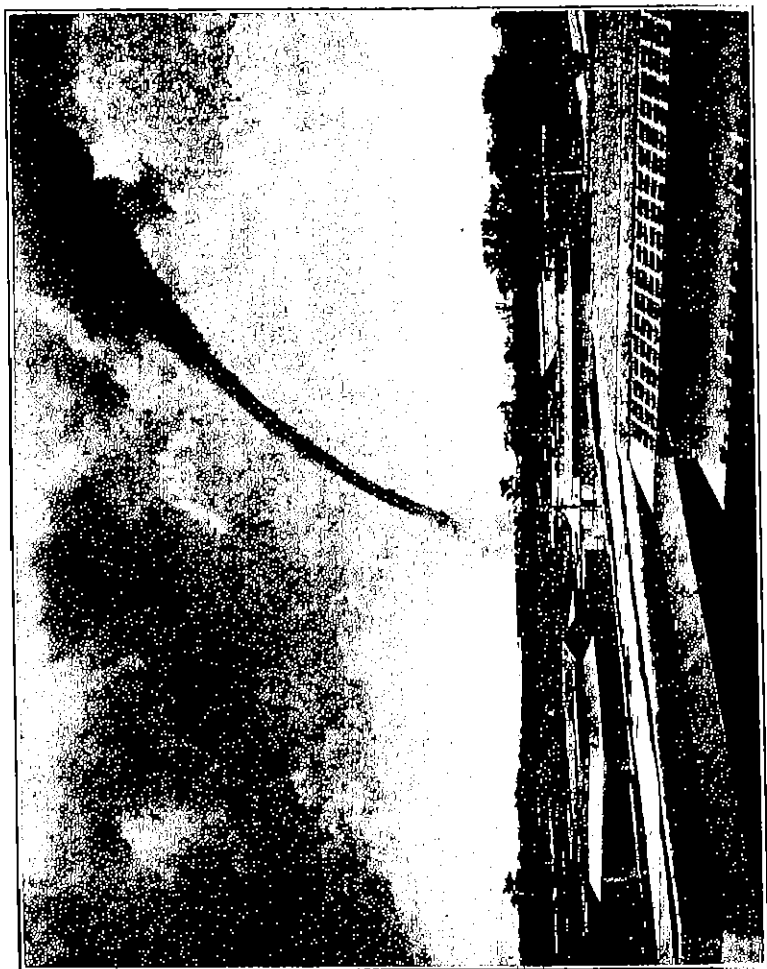


## Climatological Table for the British Empire, November, 1932

STATIONS	PRESSURE			TEMPERATURE										PRECIPITATION			BRIGHT SUNSHINE					
	Mean of Day M.S.L.	Diff. from Normal	mb.	Absolute		Mean Values						Mean	Relative Humidity %	Mean Cloud Amt	Amt	Diff. from Normal	Days	Hours per day	Per-cent. age of day possible			
				Max.	Min.	Max.	Min.	1 max. & 2 min.	Diff. from Normal	Wet Bulb												
											° F.									° F.	° F.	° F.
London, Kew Obsv.	1018.8	+4.2	58	31	49.1	40.5	44.8	+0.8	42.1	90	8.2	1.01	1.21	15	0.9	10						
Gibraltar	1019.2	+1.2	72	42	66.6	53.6	60.1	-0.4	53.9	85	4.7	3.36	3.03	10	..	..						
Malta	1018.0	+2.1	75	55	67.7	58.9	63.3	-0.6	58.2	74	6.5	4.76	1.19	14	6.2	60						
St. Helena	1014.3	+0.5	64	53	60.7	54.4	57.5	-2.1	53.6	98	9.7	0.67	..	10	..	..						
Freetown, Sierra Leone	1013.1	+2.2	89	69	86.5	73.6	80.1	-1.1	75.9	81	6.3	6.67	1.55	17	7.3	62						
Lagos, Nigeria	1011.4	+1.3	89	71	86.5	75.8	81.1	-0.6	76.3	86	7.7	2.63	0.04	9	9.7	84						
Kaduna, Nigeria	1012.9	+0.3	93	51	92.0	59.5	75.7	-0.5	63.1	63	3.7	0.00	0.21	8	..	..						
Zomba, Nyasaland	1008.5	-0.4	93	53	86.0	63.1	74.5	-1.1	64.8	55	4.1	5.26	0.18	8	..	..						
Salisbury, Rhodesia	1010.3	0.0	90	46	83.1	59.3	71.2	+0.5	59.7	45	3.8	2.39	1.21	9	7.6	59						
Cape Town	1015.1	+0.7	95	52	79.2	58.5	68.9	+4.5	60.6	63	3.3	0.34	0.75	5	..	..						
Johannesburg	1011.5	+0.6	89	43	77.9	53.7	65.8	-2.1	55.5	54	4.7	2.33	2.63	13	8.7	65						
Mauritius	1016.7	+0.6	84	63	82.4	68.2	75.3	-0.2	69.8	63	6.7	1.36	0.22	13	9.3	72						
Calcutta, Alipore Obsv.	1013.2	+1.1	90	58	81.7	67.6	74.7	+1.2	68.2	87	4.1	8.89	8.24	6*	..	..						
Bombay	1010.3	-1.7	95	70	90.4	74.1	82.3	+1.7	71.7	73	2.6	0.07	0.38	..	..	..						
Madras	1009.6	-1.7	89	69	84.3	73.7	79.0	+0.1	75.5	91	7.8	11.52	2.09	14*	..	..						
Colombo, Ceylon	1010.1	+0.1	86	70	84.0	73.9	78.9	-1.1	76.3	81	6.6	14.60	2.84	23	5.6	47						
Singapore	1009.5	+0.1	90	71	86.1	73.4	79.7	-0.9	75.8	80	3.2	4.51	5.40	15	5.6	47						
Hongkong	1016.8	0.8	81	54	75.4	66.4	70.9	+1.3	63.7	63	5.8	0.10	1.64	3	5.9	53						
Sandakan	..	..	90	73	87.4	74.8	81.1	+0.2	77.0	83	7.4	10.36	4.36	19	..	..						
Sydney, N.S.W.	1015.7	+1.9	87	52	75.4	61.1	68.3	+1.3	63.4	63	5.5	3.73	0.88	9	8.5	61						
Melbourne	1015.8	+1.4	98	43	72.5	52.1	62.3	+1.0	56.2	61	6.6	0.64	1.59	15	5.2	37						
Adelaide	1016.9	+1.7	101	43	78.3	55.4	66.9	-0.1	57.7	44	6.1	0.36	0.79	6	8.6	62						
Perth, W. Australia	1016.9	+1.5	95	49	75.2	56.9	66.1	0.0	58.8	52	5.3	0.13	0.67	5	9.8	73						
Coalgardie	1014.3	+1.2	102	47	85.8	55.5	70.7	0.0	57.1	34	3.2	0.04	0.55	2	..	..						
Brisbane	1016.9	+2.3	87	59	80.3	64.4	72.3	-1.2	66.1	60	6.3	2.84	0.91	9	8.4	63						
Hobart, Tasmania	1011.1	+1.5	89	40	67.1	48.7	57.9	+0.7	51.6	56	6.5	1.26	1.21	12	8.1	56						
Wellington, N.Z.	1015.0	+2.9	69	41	62.6	50.1	56.3	-0.5	53.1	69	6.7	1.32	2.20	7	8.6	60						
Suva, Fiji	1011.5	+0.4	88	69	83.4	73.3	78.3	+1.2	74.3	80	8.1	10.95	1.16	24	4.5	35						
Apia, Samoa	1009.1	0.4	89	72	85.7	74.5	80.1	+1.4	77.3	78	6.5	20.09	10.26	22	6.4	50						
Kingston, Jamaica	1010.3	-2.1	89	69	86.3	72.7	79.5	+0.2	71.3	83	6.2	2.67	0.36	9	6.6	58						
Grenada, W.I.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..						
Toronto	1022.4	+5.1	59	8	42.1	29.3	35.7	-1.3	31.3	81	6.2	3.26	0.63	11	3.9	40						
Winnipeg	1018.5	+1.1	46	20	26.3	10.7	18.5	-2.8	..	..	6.4	0.36	0.71	3	..	36						
St. John, N.B.	1022.4	+7.8	55	25	43.6	28.5	35.1	-1.6	33.2	81	6.7	3.56	0.85	12	3.5	..						
Victoria, B.C.	1015.5	-0.1	59	38	50.0	43.5	46.7	+2.2	45.2	94	8.5	7.45	2.04	21	2.0	22						

\* For further exceptions a rain day is a day on which 0.1 in. or more rain has fallen.





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## The Thunderstorm of May 6th, 1933

On the afternoon of Saturday, May 6th, thunderstorms were widespread in the north of England and in the Midlands. They occurred just in front of a cold-front occlusion which moved north-eastwards over the country and which was associated with a small depression which developed south-west of Ireland during the night. The thunderstorms well exemplify some of the points made by Mr. Douglas in his article in the *Meteorological Magazine* for April.

On Friday, May 5th, an occlusion had passed over England and at 13h. G.M.T. stretched from the Hebrides south-eastwards through Yarmouth to north France. To the air over England, therefore, the tag "maritime sub-polar" could be attached. An upper air record obtained at Duxford at 12h. 15m. G.M.T., however, indicated that at that time the polar air extended upwards from the surface to only about 8,000 feet. The observations made at 6h. G.M.T. the following morning showed this, for by that time the temperature right up to about 16,000 feet had fallen considerably below that of Friday morning. Conditions on Saturday morning were then very favourable for the development of thunderstorms.

The synoptic situation at 7h. G.M.T. on Saturday was as follows:—A small centre of low pressure was indicated about 150 miles west-south-west of the Scilly Isles with a

cold-front occlusion running south-eastwards to Socca in south-west France and about 100 miles south-west of Brest. The main centre of low pressure was about 200 miles west of Blacksod Point. Winds over England were south to south-east generally and were strong in the western Channel. Pilot balloon and nephoscope observations showed that there was a fairly uniform southerly current up to the cirrus level over the greater part of England at least.

At 13h. the occlusion stretched south-eastwards from Pembroke to Portland Bill and Cherbourg. Thunder was reported at Upper Heyford and Ross-on-Wye in the past weather at this hour and Ross-on-Wye had had a heavy shower. Between 13h. and 16h. Upper Heyford had a thunderstorm, and by 18h., when the front stretched from about Liverpool to just east of London, thunderstorms had occurred at Birmingham, Catterick and Harrogate. At the last two places they were still raging at the hour of observation. Thunder had occurred at Liverpool and a heavy shower at Sealand. Health resorts' reports showed also that the following places had thunderstorms during the afternoon:—Morecambe, Blackpool, Southport and Ilkley.

The speed of movement of the front after 18h. decreased considerably and it became almost stationary during the night along the east coast of England.

There seems little reason for doubt that the advance of the cold-front occlusion was the trigger action which started the thunderstorms and that they were carried along in front of the occlusion by the upper wind. The fact that they occurred mainly in the Midlands and north was probably due to the greater land track covered by the air in these regions compared with air further south. A letter from Mr. A. E. Moon, of Hastings, seems to show, however, that surface heating on the continent was responsible for a thunderstorm immediately on the front in his neighbourhood. He writes as follows, describing a line-squall. (All times are G.M.T.)

"Weather previous to the approach of the squall was fine, though cloud, consisting chiefly of alto-cumulus, began to increase about three-quarters of an hour before the squall cloud appeared. At between 16h. 30m. and 16h. 45m. heavy clouds were seen to be approaching from the south-west, the extreme front of the cloud-bank consisting of a long band of alto-cumulus castellatus of a large variety, stretching from near south-south-east to north-west. As this band of cloud advanced it gradually resolved into a layer of dense black alto-stratus but still retaining the banded formation. The approach of this cloud-bank at 16h. 45m. appeared to be very slow. Just behind the dense alto-stratus cloud there was a heavy mass of grey cloud which was of low altitude and showed signs of turbulence, especially at its southern extremity. The wreath cloud of the squall passed

overhead at a good speed towards the north-east at 17h. 3m., and simultaneously the wind, which had before 17h. been blowing light (about 10 m.p.h.) from east-south-east, suddenly whipped over to south-south-west and blew at a speed between 21 and 27 m.p.h. Behind the wreath the sky for some distance was covered with heavy blue-black cloud at a greater height than those forming the front of the squall, while nearer the horizon a grey uniform sheet of rain was gradually advancing. This did not reach the station until 17h. 20m., after which time it quickly became heavy, then very heavy at 17h. 27m. being of large drops; it became less heavy for a time at about 17h. 35m., but still continued heavy until it ceased at 18h. 37m. Thunder and lightning were observed at 17h. 42m. but no details as to distance or direction are available, but was probably not beyond four miles away; thunder was again heard, this time to the south-south-east at 17h. 49m. Weather remained dull after the cessation of the rain at 18h. 37m.

Soon after the squall of the wind to the south-south-west at 17h. 3m. the direction became south-westerly, but in about half-an-hour had again become light and variable in direction. At 18h. the direction was south-south-west, 10 m.p.h., after which it backed through south to south-east, and coming from the north-east at 18h. 30m. but not remaining in any direction long.

Thunderclouds were seen slowly developing over the sea, but not inland, during the middle of the morning, while lines of typical alto-cumulus castellatus were also seen developing."

The occlusion passed over London at about 16h. 50m., and as it became very diffuse over south-east England it is unlikely that it reached Hastings so early as 17h. 3m. The probability is that the earlier phenomena described by Mr. Moon were associated with a local thunderstorm, but in this case the storm was so close to the front that there was no way of differentiating between the thunder-squall and the front squall.

Another description of a line squall on this day was received from Mr. Donald L. Champion of Waltham Cross, Herts. His description was as follows:—"A well-marked line-squall passed here on May 6th. The morning had been fine, with little cloud, mostly cirrus, but during the afternoon much cumuliform cloud was observed to be coming from the west, becoming lower and denser as the afternoon advanced.

At 15h. the wind was ESE., force 1 and shade temperature had reached 68°F.; by 17h. the thermometer had fallen slightly to 66°F. and the ESE. wind freshened slightly to force 2. Soon after 17h. I observed a heavy bank of cloud approaching from the west-south-west; this cloud had a well-defined stratified base and reached the zenith at about 17h. 20m. At the same time the wind, in a gust of about force 6, suddenly veered to SW. and the temperature, in five minutes, fell to 61°F. By 17h. 40m.

the temperature had fallen to 58°F. and the wind lessened to about force 4, and by 18h. 10m. had abated to a steady breeze, from SW., force 3, the thermometer having resumed its slow fall, being then at 57°F. No rain fell except a slight shower at 18h. 45m.

A friend of mine, who was about two miles west of Great Missenden, which lies about 30 miles due west from here, reports that the squall struck him at about 15h. 55m."

(The times referred to in this letter are presumably B.S.T.)

In this case it appears that the squall was associated with the occlusion itself and not with a thunderstorm. The phenomena described are consistent with what happened as the occlusion passed over several telegraphic reporting stations, including London.

J. S. FARQUHARSON.

### Roll Cloud seen at Eastbourne, May 6th

During a fine afternoon on May 6th, 1933, at about 5 p.m. B.S.T. looking in a south-west direction towards Beachy Head from Eastbourne front, I observed a curious phenomenon known as a roll cloud. This cloud stretched from the back of Beachy Head to the horizon line out at sea, and was approaching broad-side on. The colour of the roll itself was white, while a heavy mass of cloud following directly behind was dark grey which suggested nimbus. As this white roll grew nearer a white straggling mass of cloud seemed to hang from the bottom of the roll cloud which gave the impression of a large white curtain hanging down. When the cloud approached Beachy Head the roll broke up into two pieces; one portion went out to sea, and the other over the hills. During the time of the approach of this cloud a dead calm prevailed but a moderate breeze blew up from a south-west direction as it passed overhead. After the front had passed, which took about 20 minutes, the spectacle vanished and steady rain fell for about half an hour.

J. MONGER.

17, St. James' Mansions, Muswell Hill, N.10. May 17th, 1933.

[For a photograph of a similar roll cloud see the illustration facing page 129 of the July, 1932, *Meteorological Magazine*.—Ed., M.M.]

### A Note on Radiation Fog

The curves which are shown in Figures 1 to 3 are, perhaps, worthy of reproduction. They are the curves of temperatures on certain occasions at heights of 143 feet, 100 feet and 4 feet above ground level at Cardington. The fourth curve in each figure is that at 4 feet above ground level over ground about 28 feet lower





than that above which the other records were made. The first, second and fourth curves were recorded by platinum resistance thermometers (unaspirated), the third curve by a bimetallic thermograph. The curves are remarkable, showing as they do a sudden fall in the temperature successively at each height and after the fall a very steady and uniform temperature. On examining the weather recorded in the mornings of these occasions it was found that a dense fog (visibility less than 200m.) was reported on each occasion. And the same was found on some other occasions when similar features were recorded though not so markedly. On each of these three occasions the wind at 50 and 150 feet was nil. Clearly the fall in temperature occurs when the fog reaches the level of each thermometer in turn, the cooling being due to radiation which is escaping from the surface of the drops composing the fog.

From such curves as the first three of each figure, it is possible to calculate the upward speed of propagation of the fog surface, as well as the depth of the inversion layer at the top of the fog (for the latter the assumption being made that the depth of the inversion does not materially change during its passage past any one thermometer); the values are given in the table below:—

		<i>Upward speed of fog surface.</i>	<i>Depth of Inversion.</i>
<i>Date (1931).</i>			
October	15th-16th	1·8 to 0·6 feet per min.	30 feet
„	26th-27th	About 0·7 „	42 „
November	16th-17th	1·5 to 0·6 „	22 „

As I have said, the fog is primarily due to radiative cooling from the surfaces of the water drops. This cooling is propagated in turn to the air by conduction and radiation. The cooling of the air to the dewpoint above the fog must be a somewhat complicated process. A radiative transfer of heat occurs from the water vapour above the fog to the fog drops themselves as well as to the water-vapour in the air within the fog, while there is, too, a transfer of heat by turbulence. It would appear that these three forms of heat transfer are all important, and so the equation of heat transfer cannot be expressed in a simple form.

A feature occurs in Fig. 3 to which Mr. Brunt\* has already alluded, namely, the fluctuations in temperature in the surface of inversions (e.g., between 5h. 20m. and 6h. 20m. G.M.T. at 143 feet). A possible explanation is that, with a suitable vertical distribution of water-vapour, the upper layers of the fog may be cooled down below the lower layers and instability may then arise within the fog which will set up convectional cells. The movement of air in these cells will give rise to an indentation of the fog's surface, which will be reproduced on the thermograph as temperature fluctuations such as those shown in Fig. 3. This

\* Notes on Radiation in the Atmosphere. By D. Brunt, London, Q.J.R. Meteor. Soc. 58, 1932, p. 389.

supposition of instability within the fog would too account for the well-known phenomena of the sudden thinning of fog over small areas, an explanation which was suggested to me tentatively by Mr. Giblett some years ago. It would be interesting to know if aircraft flying over fog ever observed such indentations from above. I know of no such case except on one occasion when the Airship R.100 flew for some hours over an extensive fog covering the Midlands. On that occasion, I understand, irregularities were seen in the fog's surface, but from the recollections of her officers there was no regular pattern evidenced. If, however, any sort of regular pattern could be identified, it might be turned to practical use by the aviators, since the size of the cells would afford a means of determining the depth of the fog.

C. S. DIRST.

### Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, May 17th, in the Society's Rooms at 49, Cromwell Road, South Kensington, Mr. R. G. K. Lomport, M.A., F.Inst.P., Vice-President, in the Chair.

*D. Brunt, M.A., B.Sc.—The adiabatic lapse-rate for dry and saturated air.*

The equation giving the saturated adiabatic lapse-rate is derived as an energy equation, and a slight approximation makes it possible to reduce this to a form suitable for direct computation. The results obtained are represented graphically, isopleths of different values of the saturated lapse-rate being shown with pressure and temperature as co-ordinates. An alternative derivation of the fundamental equation for rising saturated air is given, which, by assuming the principle of entropy from the beginning, reduces the derivation to very brief compass.

*C. S. Dirst, B.A.—Notes on the variations in the structure of wind over different surfaces.*

From an examination of anemograms in favourable situations it is found that over the sea the short-period fluctuations in wind are greater in tropical air than in polar air, although when inversions of any magnitude occur over the sea, smooth-flowing air can persist with higher velocities than over agricultural land. An example is shown of the structure of wind over desert; finally the frictional churning of the air due to a town is examined, and the consequential effects on temperature are found to be appreciable.

*C. E. P. Brooks, D.Sc., and Theresa M. Hunt.—Variations of wind direction in the British Isles since 1341.*

Regular observations of wind direction began near London in 1667, at Edinburgh in 1731 and at Dublin in 1725, and

extend, with gaps in the earlier periods, to the present day. For these three cities the resultant wind direction and "constancy" are given for each winter, summer and year. Over nearly the whole series the prevailing wind has blown from about WSW., but abnormally frequent easterly winds were recorded during the period 1740 to 1748 in London and Dublin and during the period 1794 to 1810 in London. The present century has been remarkable for the persistence of south-westerly winds. Before 1667 observations are scanty, but Merle's diary shows a dominant wind from WSW. in the years 1341 to 1343, while there is good evidence that easterly winds were abnormally frequent during the latter half of the sixteenth century.

### Correspondence

To the Editor, *The Meteorological Magazine.*

#### Cirrus Cloud Formation

On the evening of May 20th, at 18h. 35m. I was at a point about 310 ft. above Ordnance datum on Dean Hill, about  $6\frac{1}{2}$  miles east-south-east from Salisbury.

The sky at this time was almost covered with a mosaic of cirrus and patches of cirro-cumulus; but in the south-east at an altitude of about  $40^\circ$ , I observed the peculiar cloud formation shown in the accompanying sketch.



Further, in about 7 minutes, the upper half of the darker shadow became twisted spirally across the pendant as shown,

which seems to indicate that the latter was revolving in an anti-clockwise direction. At the same time the pendant became slowly elongated horizontally as if the upper portion was moving faster than the lower; and after about 15 minutes the pendant became more diffuse and finally the whole pattern merged into a continuous sheet of cirrus.

Was the pendant the "slow motion" equivalent of a "water spout" in the cirrus region?

D. L. CHAMPION.

187, High Street, Waltham Cross, Herts. May 23rd, 1933.

### Sun-Pillar seen from Hastings

This evening about 18h. 45m. I saw about 2° of what seemed to be an orange sun-pillar rising from a cloud which hid the sun. Immediately above the sun was a short segment of the 22° halo, the only part of the halo visible.

CICELY M. BOTLEY.

Guildables, 17, Holmesdale Gardens, Hastings. May 15th, 1933.

### Brilliant Rainbow, May 7th

A brilliant rainbow was observed by Mr. E. W. Montagu Murphy, of Ballinamona, Cashel, Co. Tipperary, at sunset on May 7th, 1933. The colours in the main bow were very bright and later secondary bows developed so that at 7.20 p.m. four complete bows were visible.

### Heavy Rainfalls in Scotland

On the 2nd of April rain to a depth of 6.50 inches was recorded at Dunhulladale, Loch Carron, Ross-shire. The observer confirms the measurements, the authority in a letter stating:—"it was confined to a small area here. I cannot say exactly when it commenced but it was of long duration and very heavy at times. The amount 6.50 inches is quite correct although I am sorry I cannot give the exact time it commenced or stopped. It was the greatest fall in 24 hours I have noted (commencing 1914). I heard that it was comparatively small at Achnashellach and Opinan (Gairloch) and even  $\frac{1}{2}$  mile from here it was nothing extra."

During the period 1865-1931 on only four occasions have falls greater than this been reported for a rainfall day in Scotland, namely:—

Ben Nevis Observatory,	7.20 in. on October	2nd, 1890
" " "	7.74 " " February	6th, 1894
Croy (Dalcross Castle),	7.06 " " September	25th, 1916
and Loch Quoich		
(Kinlochquoich),	8.20 " " October	11th, 1916

Other large daily values on April 2nd, 1933, were—

3.13 in. at Glenquoich,

3.60 in. at Glen Etive,

and 4.14 in. at Kinlochquoich.

A. H. R. GOLDIE.

*Meteorological Office, 6, Drumshough Gardens, Edinburgh 3. May 10th, 1933.*

### Another Thunderstorm Phenomenon

I have just received details from Mr. E. W. Cooper, of Minehead, Somerset, about a thunderstorm phenomenon which is new to me. It was observed by him and his son during a severe storm, at Minehead, in May, 1930. One observer was using a wireless set with headphones and the other was watching the storm. A sound was heard in the phones an appreciable time before the lightning was visible—in fact the listener had time to say “look out” before the other observer saw the flash. The time taken for this, together with the listener’s personal equation, must have been 0.2 second at least. I can find no reference to any similar observation. Theoretically an explanation is difficult to find, since wireless waves and visible light are both electromagnetic and are propagated through the ether with the same velocity. Yet Mr. Cooper has no doubt that the time interval was real.

It is interesting to compare this with the “vit” or “click,” which was not observed, however, on this occasion. The sequence of events there is (a) flash and “vit” together, (b) thunder. In the Cooper phenomenon the sequence is (a) sound in the headphones, (b) flash, (c) thunder-claps. Are the two phenomena related, and can anyone throw further light on the problem?

S. E. ASHMORE.

22, *Soho Road, Handsworth, Birmingham 21. May 27th, 1933.*

### Summer Thunderstorms

The comments on my article by Col. Gold in the May number of the *Meteorological Magazine* (which he was good enough to show me before sending them) do not reveal any very serious clash of opinion, but after consideration I think that some further remarks might help to clarify the position. It is extremely difficult in meteorology to be precise and accurate and to find words which convey the same ideas to all readers. The trouble arises mainly from the complexity of the atmosphere itself, but it is incumbent on meteorologists to do their best to minimise the evil. My reference to a “misleading notion” was based on statements I have seen in the past, which were not connected with forecasting in north-east France, however the “notion” may have arisen. The following points must be emphasised in con-

nexion with thunderstorms associated with south-westerly above south-easterly currents:—(a) Temperature rises in the layer where the wind veers rapidly with height; (b) temperature does not always fall at greater heights in the 12 to 24 hours before the storm though it sometimes does; (c) temperature generally exceeds the seasonal normal at all heights; (d) super-adiabatic lapse-rates are not necessarily involved, and have not hitherto been observed in such cases. Any statement of the position which gives a wrong impression on any of these points deserves to be called misleading.

I have always regarded a wind veering upwards in the lowest 5,000 feet as favourable for thunder, owing to its indicating the arrival of warm air, and have said so more than once in print. In my recent article I toned down the statement to the following\* :—" Sometimes it certainly appears as if the advection of warm air in the lower levels, associated with a wind veering upwards, increases the lapse-rate at the top of the layer affected, and helps the development of thunderstorms." This increased caution was forced on me by the figures given in the previous paragraph, which (much to my surprise) actually showed a slightly larger proportion of storms when the wind was in the south-east quadrant at both 1,000 and 5,000 feet, than when there was a SW. wind over the SE. wind. The former cases often showed some veer, but less on the average than the latter. The fact is that diurnal convectional storms are numerically preponderant (especially when the criterion is the occurrence of thunder anywhere in an area) and that these are not normally associated with much wind shearing. Layers of marked shear are usually of the nature of sloping surfaces of discontinuity, with the warmer air above, and possibly also the shear may interfere mechanically with convection of the ordinary diurnal type. I have examined the pilot balloon observation for the summer of 1931 in the south-eastern area in relation to thunderstorms reported between 13h. and 18h. in the *Daily Weather Report* (at any station in districts 1, 2 and 3), and find that the average vector change of wind with height was less on the days of afternoon thunderstorms than on the other days, the difference being slight (and perhaps of no genuine significance) in the layer from 2,000 to 5,000 feet but quite considerable in the layer from 5,000 to 10,000 feet.

The storms associated with marked shearing belong to a special category of storms of frontal type, with no marked diurnal variation. When there is a large veer with height, the simplest case is that of a warm front, with a suitable lapse-rate in the warm air mass. In most of such cases the surface wind is north of east and the upper wind is south-east or south, but some few of the storms with an upper south-west current

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\*See *Meteorological Magazine*, 68, 1933, p. 57.

are of warm front type, especially after the middle of August. In the height of the summer the solar heating on the continent is great, and forms a high lapse rate up to 5,000 feet, and it is difficult to estimate the effect of different factors. Many of the storms with a SW. over a SE. or S. wind accompany cold fronts (or cold front occlusions) from the Atlantic, and the steep horizontal temperature gradient in the warm air is not in general directly connected with the front itself, but is an additional effect peculiar to the summer months. (The reverse effect in winter is not quite analogous, since the surface cooling only diffuses upward very slowly, and has little effect on wind structure above 1,500 feet.) Even in summer many cold front storms have a more or less "solid" current in front of them. The severe storm early on August 12th, 1932,\* was of this type, as shown by the pilot balloon ascent at Felixstowe.

A wind backing with height is usually found behind a cold front, after the thunderstorms, though sometimes belated storms occur behind the front, entirely in the warm current above. Storms in the polar air are of a different type.

As Col. Gold suggests in his note, each case must be considered on its merits, and the upper wind used in conjunction with other factors. An upper south-west current is favourable for thunder if it tends to bring over a front, or if it brings damper air, though the surface distribution of humidity must be interpreted with caution. Over the sea or on the coast there may be a very shallow layer of damp air, with dry air above. Over the land, on the other hand, the vertical gradient of absolute humidity is reduced by convection, so that a shallow layer of damp air is unlikely, especially in the afternoon.

C. K. M. DOUGLAS.

May 30th, 1938.

### The Duration of a Lightning Flash

I am in considerable agreement with Mr. Lutkin's views as to the possible constitution of the lightning flash. I have always looked on it as an oscillatory phenomenon, and indeed it was for that reason I regarded the photo I sent this *Magazine* in December as interesting, for it seemed to show the persistence of *something* during the  $\frac{1}{8}$  second of the record.

Thus the interesting points about my ciné record seemed to me to be (1) the practical identity (as far as I could see) of the shapes of the first four of the five pictures, and (2) the fact that in the last faint photo, while there is a faint thread running through the flash, there are very evident "blobs" left in the positions of the darker portions of the first four pictures. These "blobs" unfortunately have not come out well in the reproduc-

\*See *Meteorological Magazine*, 67, 1932, pp. 186-90.

tion, but I regarded them as evidence of the fading away of something.

Whether the current which caused the flash was unidirectional or oscillatory does not seem to affect this point that something—possibly corresponding to Mr. Lutkin's orange red glow—did have an extended existence in time. A slow-motion picture of a lightning flash would be a very interesting and welcome method of settling the point, though I fear it might involve the use of quite a number of feet of film before the time and the place and the loved one were found all together.

M. MCCALLUM FAIRGRIEVE.

37, Queens Crescent, Edinburgh. May 10th, 1933.

### A Tornado at Peshawar

On April 5th, during the passage of a well-marked depression across the extreme north of north-west India, a tornado occurred in the vicinity of Peshawar Cantonment causing damage to crops, trees, kutchia buildings, &c.

The phenomenon was first seen at 12h. 35m. I.S.T. as a funnel-shaped appendage to a mass of dense and towering cumulonimbus cloud, and was preceded by a slight hailstorm. The funnel soon reached to the ground and by 12h. 45m., when the photograph (reproduced as the frontispiece of this number of the *Magazine*) was taken, it had developed into a curved dark column of upward-spiralling winds. Subsequently the twisting column of air and water vapour became distorted and attenuated, finally disappearing at 13h. 10m.

The diameter was probably about 30 yards and the length of path about 5 miles. As the tornado—an almost unknown phenomenon in this part of the world—only lasted for 35 minutes, and, fortunately passed over open country, very little damage was done.

On the other hand, the storm did not come near enough to the Meteorological Office to affect the recording instruments to any marked degree. It appears certain, however, that the phenomenon was the result of vigorous convection between relatively strong and superadjacent counter-currents of different origin.

A full account and discussion of the storm is being prepared for subsequent publication.

R. G. VERYARD.

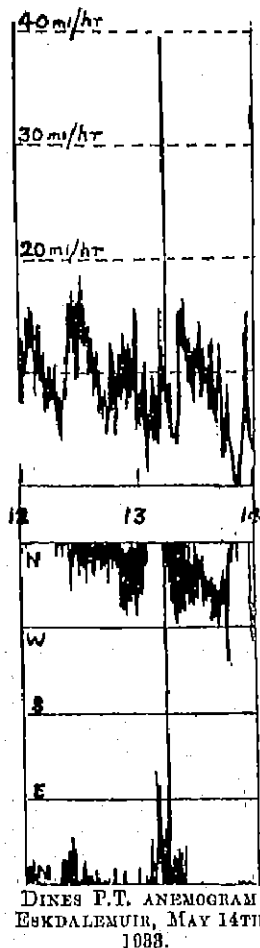
No. 1 (Indian) Group Headquarters, R.A.F., Peshawar. April 17th, 1933.

### Small Whirlwind at Eskdalemuir

A small but violent whirlwind crossed the Observatory grounds from north to south at 13h. 12m. G.M.T. to-day, Sunday, May 14th, 1933. A strong easterly wind was first noticed at a



point about 70 yards north-east of the anemometer mast, and immediately afterwards a well-defined "whirl," two or three feet in diameter and containing pieces of grass, twigs and other debris, was seen to move south at a speed of about 10 m.p.h., passing through the gap between the main Observatory building and one of the houses, some 30 yards to the east of the anemometer mast.



Examination of the anemogram shows an isolated gust of 40 m.p.h., but it is impossible to tell from what direction the wind came, as the vane made a complete revolution at that time. The wind immediately before and after was 8 m.p.h. from north. Pressure as shown on the float barograph fell and rose about 1 mb. almost instantaneously. The weather was "bc" at the time with 6/10 fair weather cumulus and strato-cumulus at 3,500 ft., and as far as could be seen the whirlwind did not extend to that height. Temperature remained fairly steady at 57°F., and relative humidity 35 per cent. in the large Stevenson screen.

The morning had been rather warm with strong sunshine, and presumably the whirlwind was moving from the higher hills down the valley along the wind, although its course could not be followed owing to the configuration of the ground.

Later in the evening at about 17h. 30m. G.M.T. a violent agitation of the trees was heard to the north-east of the Observatory, about 300 yards from the anemometer, as if another small whirlwind was passing, but no strong gust was recorded on the anemometer as in the earlier case.

LESLIE H. J. STONE.

*Eskdalemuir Observatory, Langholm, Dumfriesshire. May 18th, 1933.*

### Slow-moving Clouds

As evidence of the unusually small movement of air at 2,500-3,000 feet in this district on Sunday, April 30th, 1933, the following observation was considered noteworthy.

Cumulus clouds moved slowly from south-west during the day

with gradually decreasing velocity. By 5 p.m. G.M.T. it was calm and a detached cloud remained stationary (*i.e.*, not moving 100 yds.) overhead from 5 p.m. to 8 p.m., after which its identity was lost among increasing clouds. Cirrus could be seen above moving from south-west or west-south-west.

R. M. POULTER.

28, Pinner Park Avenue, Headstone Lane, Harrow. May 5th, 1933.

## NOTES AND QUERIES

### The New Primary Standard Barometer at the National Physical Laboratory

In 1912 the work of verifying barometers was transferred from Kew Observatory to the National Physical Laboratory at Teddington. The original standard barometers were left at Kew, while a new large bore working standard of the Fortin type was provided for the N.P.L., and carefully compared with the old Kew standards. The late Sir George Beilby, F.R.S., gave a sum of £200 for the purpose of constructing a new primary standard for use at the Laboratory, and a recent paper\* in the *Proceedings of the Royal Society* gives a full description of its construction and details.

With modern systems of pumping it is comparatively simple to obtain a very low pressure within an enclosure. It was, therefore, not necessary to construct the new standard barometer of glass tubing permanently sealed off. The barometer consists essentially of a U-tube bored in a solid block of stainless steel. The upper end of the longer arm is connected with a mercury vapour condensation pump, and the other arm is open to the air. The mercury surfaces are observed by means of two micrometer microscopes and "collimators," through optically flat and parallel glass windows placed in pairs and sealed on to specially ground surfaces of the steel. Great attention has been devoted to the method of reading, which is described in detail; briefly, the level of the mercury is taken as midway between the real image of a horizontal cross-wire and its reflection in the mercury surface. The microscopes are mounted on a massive carriage. After the microscopes have been adjusted on the upper and lower surfaces of the mercury the carriage is moved through a few inches transversely and readings can then be taken through the microscopes on the scale of inches. The temperature of the mercury column is obtained from a thermometer with a bulb thirty inches long, which is completely immersed in mercury in a hole bored through the length of the stainless steel block; corrections were determined to the nearest  $-0.02^{\circ}\text{C}$ . The line

\*A new primary standard barometer. By J. E. Sears, Jun. and J. S. Clark. London, *Proc. R. Soc.*, 130, 1933, pp. 130-46.

standard is of invar. There is also a reservoir provided with a plunger by means of which the mercury can be drawn below the level of the windows when the barometer is not in use.

The new primary standard has been compared with the semi-portable standard and with the working standard Fortin at the Laboratory. As a result of a number of readings, the latter was found to read .0015 inch above the new primary standard, the individual differences ranging from .0001 inch to .0029 inch. The uncertainty of a single reading of the new standard is about .0002 inch, while that of the working standard Fortin is about .0006 inch.

A letter from Mr. J. E. Sears to Dr. F. J. W. Whipple states that the standard Fortin barometer, which was compared with the Kew standards in 1912 and 1914, has probably not changed its index error by more than .001 inch since 1914. The recent comparisons of this standard Fortin barometer at the N.P.L. with the new primary standard therefore show that the Kew standards were not in error by more than  $\pm .001$  inch in 1912 and 1914. This is a matter for great satisfaction. The Kew standards consist of two barometers with very large cisterns and large tubes set up in 1855 and 1859 respectively, together with a cathetometer set up in 1876. The "old" standard barometer is the one set up and described by John Welsh.\* The "new" one was erected because it was feared that the "old" one had been damaged by workmen. The consistent results of the recent tests indicate not only that the barometers were well made in the first instance but also that the vacua have been maintained (in glass over mercury) for three-quarters of a century.

### **The Proportion of the annual Rainfall occurring on the wettest days of the year**

With reference to Mr. R. C. Sutcliffe's article in the October issue, the following information relating to British stations may not be without interest:—

(a) In *British Rainfall*, 1926, page 274, it was shown that the correlation between annual rainfall totals for the 35 years, 1881 to 1915, and the number of rain-days (0.01 in. or more) was +0.48, while with wet days (0.04 in. or more) the correlation is greater, being +0.63. So that about 40 per cent. of the variation in the number of wet days from year to year can be associated directly or indirectly with the variation of rainfall amounts.

(b) In *Water and Water Engineering*, March, 1932, page 120, some statistics are given of the daily rainfall amounts for ten years as recorded at Camden Square (London) and Dungeon

\* London, Phil. Trans. R. Soc. A. 140, (1856), p. 507.

Ghyll, in the English Lake District. These stations were selected as having widely different averages, viz., 24·5 in. and 109·3 in. respectively, and the average number of rain-days also differs widely, owing to the steady increase in the number of days with rain from the south-east to the north-west of England and Wales. In spite of these differences the proportions of the total annual rain contributed by the wettest days of the year (not necessarily consecutive) are similar. The values given below are the means of the percentages obtained for each of the ten years:—

<i>Number of Days</i>			<i>Camden Square</i>	<i>Duncheon Ghyll</i>
			<i>Per cent. of</i>	<i>Per cent. of</i>
			<i>Annual Rainfall</i>	<i>Annual Rainfall</i>
7	...	...	22·3	17·7
15	...	...	37·5	30·1
30	...	...	57·0	47·6
50	...	...	73·8	64·0
70	...	...	84·2	75·4
100	...	...	93·2	86·8
150	...	...	99·0	96·4
170	...	...	99·8	98·1

These statistics show that in England about 20 per cent. of the total rainfall occurs during the wettest seven days of the year, 50 per cent. occurs during about 30 days, and 75 per cent. during about 60 days.

J. GRASSPOOL.

### **L'Association française pour l'Avancement des Sciences**

The Annual Congress of l'Association Française pour l'Avancement des Sciences will be held at Chambéry (Savoie) during July. The President of Section VII, Meteorology and Geophysics, is M. Wehrlé, Assistant Director of the Office National Météorologique, Paris. The programme includes discussions on a number of meteorological subjects, but the situation of Chambéry at the foot of the Alpine massif gives especial interest to that on the influence of relief on atmospheric phenomena, notably in the Alps.

Visitors to the Congress, and papers for reading and discussion, will be welcomed. If authors are unable to be present in person, M. Wehrlé will be pleased to present papers on their behalf.

### **Meteorological Society of Chile**

A circular dated December 14th announced the formation of the "Sociedad Nacional de Meteorología," the address of which is "Casilla 717, Santiago de Chile."

The study of meteorology has been actively followed in Chile for many years, and we wish the new Society all success in continuing the work.

### **New Meteorological Stations in Malaya**

The annual report of the Federated Malay States Survey Department contains the news that, in addition to the several meteorological branch stations, telegraphic reporting stations have been established at Ipoh and Seremban, under the direction of, respectively, the Hydraulic Engineer, Perak, and the Medical Officer, Seremban Hospital. Arrangements have also been made with the Government of British North Borneo whereby conditions at Sandakan are now cabled twice daily to the Office in Singapore.

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### **New Meteorological Station in Formosa**

A meteorological station was formally opened on Mt. Alishan in central Formosa, on March 15th. The buildings vary somewhat in elevation, but stand between seven and eight thousand feet above sea level. The new station is supplementary to the Central Observatory in Taihoku and the Marine Meteorological Station in Takao, the latter of which was established in 1895 on the site of the old British Consulate.

The co-operation of the new station should add considerably to the reliability of the already valuable weather reports from Formosa, where the gradual development of military, and commercial aviation will render such information more and more essential. Facilities for a variety of other scientific studies and observations have also been provided at the new observatory.

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### **News in Brief**

A course of training for meteorological observers was held in the library of the Meteorological Office on May 9th and 10th, 1933, and was attended by twenty persons.

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### **The Weather of May, 1933**

Pressure was below normal over the United States and Canada (except for California and part of the North-West Territory) across the North Atlantic (including Madeira and the Canary Islands, southern British Isles, Denmark, Netherlands, northern France to central and eastern Europe, the greatest deficits being 4.8 mb. at Point Barrow, 7.2 mb. at 50°N. and 5.5 mb. at Astrakhan. Pressure was above normal at Spitsbergen, Iceland, Norway, most of Sweden, northern Russia, the Iberian Peninsula, western Mediterranean and southern North Atlantic (including the Bermudas and Azores), the greatest excesses being 6.8 mb. at Jan Mayen and 2.7 mb. at Madrid. Temperature was above normal at Spitsbergen and in the western regions of Europe, but below normal in eastern Gothaland and Svealand in Sweden and in central Europe, rainfall was deficient at Spitsbergen and most of Scandinavia but in excess in central Europe.

The outstanding feature of May over the British Isles was the prevalence of thundery conditions; temperature was above normal generally, but sunshine was deficient and rainfall variable. Pressure was high over the British Isles during the first day of the month, but on the 2nd a depression off the Bay of Biscay, which was moving slowly northwards, caused unsettled weather with easterly winds in the south. In Scotland the 2nd was a very sunny day with 14.2 hrs. bright sunshine at Inverness and 13.6 hrs. at Aberdeen. By the 3rd, however, the influence of the depression had spread also over Scotland, and from then until the 11th a complex low-pressure system lay over the British Isles maintaining unsettled conditions. Thunderstorms occurred on the 1st-3rd, 6th and 9th, and winds were strong locally at exposed places on a few days. Rainfall during this period was usually slight or moderate, but some isolated heavy falls occurred on the 6th, 1.91 in. at Limerick, 1.30 in. at Skegness, and 1.12 in. at Jersey, while sunshine was variable, 14.2 hrs. occurred at Tice on the 10th. During the 12th, 13th and 14th the weather was fair to cloudy in England and Ireland, but in Scotland there was much sunshine generally, Tice had 13.6 hrs. and Oban 13.3 hrs. on the 13th. On the 14th the fine weather was spreading further south, Malin Head had 14.7 hrs. and Southport and Douglas both 14.5 hrs. bright sunshine; while the 15th was fine over the whole country. On the 16th the depression over the Atlantic extended its influence eastwards over the British Isles and the weather became cloudy and unsettled, with slight rain locally except in south-east England until about the 20th. Pressure became high over the country on the 21st, and except for small breaks remained so until nearly the end of the month. Thunder was heard frequently and thunderstorms occurred in some parts of the country most days; these were accompanied by heavy rain in the south on the 23rd, 2.47 in. at Banstead (Surrey) and 1.85 in. at Woking. Other isolated moderate falls later in the month were also associated with thunderstorms, 0.91 in. at Ross-on-Wye on the 27th, and 0.71 in. at Lympne on the 29th. During the first part of this period temperature was high, reaching 81°F. at Tottenham on the 23rd, and 79°F. at Tottenham on the 22nd, and Croydon and Tunbridge Wells on the 23rd; sunshine records were good except in the north. Temperature, however, fell in the north about the 24th and in the south on the 25th. The 26th was a generally sunny day, and from then to the 31st sunshine records were variable but mainly good. The Atlantic depression moved slightly eastwards on the 30th bringing rain to Ireland on that day, 0.83 in. fell at Valentia, but on the 31st the weather was again improving in the west. The distribution of bright sunshine for the month was as follows:—

(continued on page 128)

## Rainfall: May, 1933: England and Wales.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>London</i>	Camden Square .....	1.69	90	<i>Leis.</i>	Thornton Reservoir ...	2.01	100
<i>Kent</i>	Tenterden, Ashenden...	1.74	111	"	Belvoir Castle .....	1.51	72
"	Folkestone, Boro. San.	2.49	...	<i>Kut</i>	Ridlington .....	1.43	71
"	St. Peter's, Hildersham	...	...	<i>Lincs.</i>	Boston, Skirbeck .....	1.50	80
"	Eden'hdg., Folcomhurst	2.00	156	"	Oranwell Aerodrome ...	1.28	71
"	Sevenoaks, Speldhurst	...	...	"	Skegness, Marine Gdns	1.52	80
<i>Sus.</i>	Compton, Compton Ho.	3.22	145	"	Louth, Westgate .....	1.68	83
"	Patching Farm .....	2.67	144	"	Brigg, Wrawby St. ...	1.00	...
"	Eastbourne, Wil. Sq.	1.28	74	<i>Notts.</i>	Worksop, Hodsok ...	2.23	112
"	Heathfield, Barklye ...	1.55	86	<i>Derby.</i>	Derby, L. M. & S. Rly.	1.52	80
<i>Hants.</i>	Ventnor, Roy. Nat. Hos.	2.39	141	"	Buxton, Terr. Slopes	1.70	58
"	Fordingbridge, Oaklands	2.03	98	<i>Ches.</i>	Runcorn, Weston Pt. ...	1.51	100
"	Ovington Rectory .....	1.77	81	<i>Lancs.</i>	Manchester, Whit Pk.	1.70	83
"	Sherborne St. John ...	2.02	104	"	Stonyhurst College ...	1.77	92
<i>Herts.</i>	Welwyn Garden City...	1.95	...	"	Southport, Hesketh Pk	1.62	77
<i>Bucks.</i>	Slough, Upton .....	1.47	87	"	Lancaster, Grog Obsy.	3.10	125
"	H. Wycombe, Blackwell	1.31	...	<i>Yorks.</i>	Wath-upon-Dearne ...	2.10	100
<i>Oxf.</i>	Oxford, Mag. College...	1.52	85	"	Wakefield, Clarence Pk.	2.45	124
<i>Nor.</i>	Pitsford, Sedgebrook...	1.43	75	"	Oughtershaw Hall ...	3.50	...
"	Oundle .....	1.61	...	"	Wetherby, Ribston H.	3.04	147
<i>Beds.</i>	Woburn, Crawley Mill	1.87	90	"	Hull, Pearson Park ...	1.92	100
<i>Cam.</i>	Cambridge, Bot. Gdns.	2.02	115	"	Holme-on-Spalding ...	2.65	...
<i>Essex.</i>	Chelmsford, County Lab	1.42	90	"	West Witton, Ivy Ho.	3.38	150
"	Lexden Hill House ...	1.18	...	"	Felixkirk, Mt. St. John	2.37	120
<i>Suff.</i>	Hangley House .....	1.03	...	"	York, Museum Gdns.	2.20	113
"	Campsea Ash .....	1.60	113	"	Pickering, Huggate ...	2.81	143
"	Lowestoft Sec. School	1.60	99	"	Scarborough .....	1.51	70
"	Bury St. Ed. Westloy H.	1.50	80	"	Middlesbrough .....	1.08	104
<i>Norw.</i>	Wells, Holkham Hall	1.82	113	"	Balderdale, Hury Res.	...	...
<i>Wills.</i>	Dovizes, Higholero .....	2.20	122	<i>Durh.</i>	Ushaw College .....	2.80	132
"	Calne, Castleway .....	2.40	131	<i>Nor.</i>	Newcastle, Town Moor	1.40	69
<i>Dor.</i>	Evershot, Melbury Ho.	2.30	117	"	Bellingham, Highgreen	1.87	78
"	Weymouth, Westham ...	1.66	102	"	Lillburn Tower Gdns...	1.54	67
"	Shaftesbury, Abbey Ho.	2.54	120	<i>Cumb.</i>	Carlisle, Sealby Hall	2.08	87
<i>Devon.</i>	Plymouth, The Hoe ...	1.38	91	"	Borrowdale, Southwaite	4.50	65
"	Holne, Church Pk. Cott.	3.22	101	"	Borrowdale, Moraine ...	4.41	...
"	Teignmouth, Don Gdns.	1.55	85	"	Keawick, Ilgh Hill...	3.03	95
"	Onlompton .....	2.34	108	<i>West.</i>	Appleby, Castle Bank	3.43	150
"	Sidmouth, Sidmoumt...	2.24	114	<i>Mon.</i>	Abergavenny, Larch...	2.88	108
"	Barnstaple, N. Dev. Ath	2.35	113	<i>Glam.</i>	Ystalyfera, Worn Ho.	2.21	63
"	Dartm'r, Cranmore Pool	3.00	...	"	Cardiff, Ely P. Stn. ...	1.75	70
"	Okehampton, Uplands	2.84	106	"	Treherbert, Tynywann	2.20	...
<i>Corn.</i>	Redruth, Trewirgie ...	2.77	120	<i>Carm.</i>	Carnarthen Friary ...	2.21	80
"	Penzance, Morrab Gdn.	2.74	124	<i>Pemb.</i>	Haverfordwest, School	2.43	97
"	St. Austell, Trevarna ...	3.51	145	<i>Card.</i>	Aberystwyth .....	1.19	...
<i>Soms.</i>	Chawton Mendip .....	2.02	78	<i>Rad.</i>	Birm W.W. Tyrnynydd	2.22	65
"	Long Ashton .....	2.22	105	<i>Mont.</i>	Lake Vyrnwy .....	1.55	40
"	Street, Millfield .....	1.86	97	<i>Wint.</i>	Scotland Aerodrome ...	1.10	50
<i>Glos.</i>	Blockley .....	1.60	...	<i>Mer.</i>	Dolgelly, Bontddu ...	2.04	50
"	Cinnacator, Gwynfa ...	1.92	93	<i>Carn.</i>	Llandudno .....	1.10	59
<i>Here.</i>	Ross, Birchlea .....	2.11	99	"	Snowdon, L. Llydaw ...	4.05	...
<i>Salop.</i>	Church Stretton .....	1.37	53	<i>Ang.</i>	Holyhead, Salt Island	1.40	76
"	Shifnal, Hatton Grange	1.85	90	"	Lligwy .....	1.00	...
<i>Staffs.</i>	Market Drayton, Old Sp.	1.53	72	<i>Isle of Man</i>			
<i>Worc.</i>	Ombersley, Holt Lock	1.44	70		Douglas, Boro' Com. ...	2.33	92
<i>War.</i>	Alcester, Ragley Hall...	1.37	67	<i>Guernsey</i>			
"	Birmingham, Edgbaston	2.28	107		St. Peter P't. Grange Rd	1.45	85

## Rainfall: May, 1933: Scotland and Ireland.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
Wig.	Pl. William, Monreith	2.01	85	Suth.	Melvieh	.08	48
	Now Lanes School	2.79	08		Loch More, Achfury	1.38	31
Kirk.	Dalry, Glendarroch	4.24	135	Ork.	Wick	.72	95
	Carsphairn, Shiel	3.70	88		Doorness	1.43	72
Dumf.	Dumfries, Orlinton, R.L.	3.02	117	Sherk	Lerwick	.09	33
	Eskdalemuir Obs.	2.52	78	Cork	Caltragh Rectory	4.76	...
Roeb.	Branxholm	2.50	111		Dunmanway Rectory	5.44	160
Selk.	Ettrick Manse	2.22	00		Cork, University Coll.	4.57	202
Pech.	West Linton	1.92	...		Ballinacra	4.53	101
Berw.	Marchmont House	.80	30	Kerry.	Valentia Obs.	4.03	146
E. Ind.	North Berwick Res.	1.00	55		Geamhameen	5.70	109
Midl.	Edinburgh, Roy. Obs.	1.60	81		Killarnoy Asylum	...	...
Lea.	Auchtyfurdle	...	...		Darrynane Abbey	3.28	108
Ayr.	Kilmarnock, Kay Pk.	2.11	...	Wat.	Waterford, Gortmore	3.62	157
	Girvan, Pinnore	2.12	71	Tip.	Neenagh, Oss. Lough	3.85	150
Renf.	Glasgow, Queen's Pk.	2.63	108		Roscrea, Timoney Park	1.42	...
	Greenock, Prospect H.	3.02	105		Cashel, Ballinamona	4.24	177
Dute.	Rothsney, Ardeneraig	3.34	...	Lim.	Fyness, Coolmanes	4.15	178
	Dougarie Lodge	2.12	...		Castlecummal Rec.	4.67	...
Ary.	Ardgour House	3.27	...	Clare.	Inagh, Mount Callan	0.03	...
	Glen Elvie	4.26	86		Broadford, Hurdlest'n.	5.06	...
	Oban	2.55	84	Wexf.	Gorey, Courtown Ho.	2.05	136
	Poltalloch	3.08	127	Kilk.	Kilkenny Castle	2.20	104
	Inveraray Castle	4.03	118	Wick.	Rathnew, Clonmannon	3.10	...
	Islay, Ballahus	3.03	114	Carl.	Hacketstown Rectory	3.30	130
	Mull, Benmore	3.60	...	Leis.	Blandsfort House	2.21	91
	Tires	2.30	90		Mountmellick	2.04	...
Kenr.	Loch Leven Slides	1.05	08	Offaly.	Birr Castle	2.02	91
Perth.	Loch Du	3.30	73	Kilbr.	Monastererevin	...	...
	Balquhider, Stronva	2.08	...	Dublin	Dublin, FitzWm. Sq.	2.82	138
	Orkell, Strathearn Hyd.	2.02	81		Balbriggan, Ardgillan	1.00	04
	Blair Castle Gardens	1.52	75	Meath.	Boonpare, St. Cloud	1.00	...
Angus.	Kettins School	1.35	50		Kells, Headfort	1.87	00
	Peatals House	1.47	...	W.M.	Monro, Coolatoro	1.00	...
	Montrose, Sunnyside	...	...		Mullingar, Bolvadora	2.13	87
Aber.	Braemar, Bank	1.47	02	Long.	Castle Forbes Glus.	2.30	80
	Logie Goldstone Sch.	.07	27	Gul.	Ballynahinch Castle	4.44	123
	Aberdeen, King's Coll.	.97	42		Galway, Grammar Sch.	3.35	...
	Fyvie Castle	.94	30	Mayo.	Malaherry	3.70	...
Moray.	Gordon Castle	.06	31		Westport House	2.44	80
	Grantown-on-Spey	...	...		Delphi Lodge	4.78	79
Nairn.	Nairn	...	...	Sligo.	Markree Obs.	2.80	102
Inw's.	Ben Alder Lodge	1.37	...	Clacken.	Bellarhat, Olovahill	2.60	108
	Kingsisle, The Breches	1.18	...	Bern.	Enniskillen, Portora	2.75	...
	Loch Quoich, Loan	1.98	...	Arm.	Armagh Obs.	2.57	108
	Glenquoich	1.72	81	Down.	Fossanny Reservoir	5.92	...
	Inverness, Olduthol R.	1.04	...		Seaford	2.81	107
	Arisaig, Fairo-m-Aguir	...	...		Dunaghadco, C. Stn.	2.21	07
	Fort William, Glasdrum	2.40	...		Banbridge, Milltown	2.42	107
	Skye, Dunvegan	1.10	...	Antr.	Belfast, Cavohill Rd.	2.87	...
	Barra, Skallary	1.54	...		Aldergrove Aerodrome	1.03	72
R & O.	Alness, Ardross Castle	1.12	43		Ballymena, Harryville	2.44	85
	Ullapool	.80	35	Lon.	Londonderry, Oeggan	2.54	97
	Achnashellach	1.40	33	Tyr.	Omagh, Edensol	1.93	75
	Stornoway	.02	30	Don.	Malm Head	1.94	...
Suth.	Lairg	1.33	52		Milford, The Manse	1.00	80
	Tongue	1.40	50		Killyboga, Rookmount	2.24	02

ERRATA: Loch Quoich, Loan, April, for 8.10 read 18.10

Glenquoich, " " 10.00 " 0.00

Achnashellach " " 0.43 " 10.48

Stornoway " " 18.85 " 2.85



## Climatological Table for the British Empire, December, 1932

STATIONS	PRESSURE			TEMPERATURE							Relative Humidity	PRECIPITATION			BRIGHT SUNSHINE	
	Mean of Day from M.S.L.	Diff. from Normal	mb.	Absolute		Mean Values				Mean Cloud Am't		Days	Diff. from Normal	Hours per day	Per-cent-ages of possible	
				Max.	Min.	Max.	Min.	max. 1/2 min.	Diff. from Normal							
																° F.
London, Kew Obsy.	1019.3	+5.6		55	30	46.3	42.7	38.5	+2.4	40.4	6.9	8	1.83	1.6	20	
Gibraltar	1020.0	-0.1		70	44	62.3	56.3	50.3	+0.3	51.0	5.9	19	1.64	5.6	57	
Malta	1023.2	+7.0		70	50	64.3	60.5	56.8	+2.6	55.1	6.5	8	2.41			
St. Helena	1013.2	-0.5		71	55	64.4	60.9	57.3	-0.8	57.8	9.6	12				
Freetown, Sierra Leone	1012.6	+1.7		88	69	85.7	74.1	67.9	+1.5	76.0	4.3	4	1.12			
Lagos, Nigeria	1010.7	+0.7		91	71	88.6	75.1	81.9	+0.1	75.0	6.4	0	0.81	7.6	65	
Kaduna, Nigeria	1012.8	+1.5		98	48	91.1	73.0	54.9	-0.3	55.7	1.3	0	0.00	8.8	77	
Zomba, Nyasaland	1007.9	-0.4		92	63	81.9	73.8	65.7	+0.7	68.4	7.3	21	2.74			
Salisbury, Rhodesia	1010.4	-0.8		83	56	77.2	68.9	60.6	+0.6	60.5	8.2	22	0.81	4.4	33	
Cape Town	1014.5	+0.2		93	52	77.5	66.5	59.6	-0.7	60.5	3.5	6	0.80			
Johannesburg	1009.7	-0.1		86	49	77.5	66.3	55.1	+0.8	57.5	5.5	19	2.39	8.0	58	
Mauritius	1015.3	+1.3		90	64	83.5	69.4	67.5	-1.8	71.4	6.0	16	3.17	9.0	63	
Calcutta, Alipore Obsy.	1015.2	+0.5		83	55	78.6	68.7	58.9	+2.2	59.5	0.8	0*	0.34			
Bombay	1013.1	-0.4		93	64	87.5	78.1	70.1	+1.4	68.3	0.8	0	0.00			
Madras	1013.6	+0.1		85	65	82.9	76.2	69.5	-0.5	72.0	4.0	3*	2.28			
Colombo, Ceylon	1011.1	+0.8		89	67	85.4	78.5	71.7	-1.0	74.0	5.0	12	0.61	7.3	62	
Singapore	1009.6	-0.1		90	71	86.7	79.7	72.8	-0.2	75.3	7.1	15	8.10	5.8	48	
Hongkong	1020.1	+0.4		79	47	67.7	58.5	53.5	+0.1	56.7	5.9	6	3.08	5.4	50	
Sandakan				91	72	84.7	79.3	73.9	-0.9	78.5	8.5	25	11.64			
Sydney, N.S.W.	1010.6	+1.3		97	54	76.2	62.1	69.1	-1.0	63.9	6.3	12	1.41	8.6	60	
Melbourne	1012.0	-0.7		94	46	73.0	62.5	52.1	-2.3	56.0	6.0	6.2	2.06	7.4	50	
Adelaide	1013.5	+0.3		103	48	80.6	68.8	57.0	-2.3	57.0	5.1	6	0.72	9.8	68	
Perth, W. Australia	1013.2	+0.0		96	50	80.6	73.9	69.9	-1.5	60.3	4.8	2	0.20			
Coalgate	1012.0	+0.8		106	45	89.2	73.9	66.6	-1.2	67.3	5.6	5.6	2.49			
Brisbane	1011.7	+0.3		91	62	83.8	75.2	68.6	-1.7	52.0	5.4	7.1	2.47	0.48	46	
Hobart, Tasmania	1007.9	+1.8		89	43	67.7	49.4	58.5	-1.6	54.6	6.9	27	0.62	7.0	35	
Wellington, N.Z.	1013.3	+1.6		76	44	65.1	58.6	52.1	-1.1	75.6	8.2	9	1.47	4.6	35	
Suva, Fiji	1008.0	-0.6		91	72	85.8	80.1	74.5	+1.1	75.6	7.5	13.99	1.35	7.0	54	
Apia, Samoa	1007.7	-0.6		89	72	85.8	80.8	75.7	+1.5	77.7	6.6	24	1.35	7.3	66	
Kingston, Jamaica	1013.6	-0.4		91	66	87.4	78.6	69.8	+0.9	67.3	3.7	3	1.48			
Grenada, W.I.																
Toronto	1019.2	+1.6		57	2	36.9	30.4	23.9	+3.3	26.7	7.2	8	0.42	2.7	30	
Winnipeg	1015.8	+2.9		58	34	12.4	2.7	-7.0	-3.1	4.2	4.2	0	0.94	0	39	
St. John, N.B.	1015.7	+1.7		55	—	37.0	29.3	-2.7	+4.9	25.3	5.8	11	1.88	3.6	41	
Victoria, B.C.	1018.5	+1.8		52	18	42.0	38.5	-3.1	+2.6	36.1	6.8	15	1.83	2.9	35	

\* For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen.

# Climatological Table for the British Empire, Year 1932.

STATIONS	PRESSURE		TEMPERATURE								Relative Humidity.	Mean Cloud Amt.	PRECIPITATION		BRIGHT SUNSHINE		
	Mean of Day M.S.L.	Diff. from Normal	Absolute		Mean Values.					Mean			Am't in.	Diff. from Normal	Days	Hours per day	Per-cent. per possible
			Max.	Min.	Max.	Min.	1/2 and 3/4 min.	Dif. from Normal	Wet Bulb								
London, Kew Obsv.	1016.4	+1.0	92	22	56.7	44.1	50.4	+0.7	87	7.1	21.99	-1.81	153	3.4	26		
Gibraltar.	1017.8	-0.1	91	38	71.1	56.0	63.5	-0.7	82	4.7	37.89	2.07	103	..	..		
Malta .....	1017.1	+1.7	92	41	70.7	60.6	65.7	-0.4	76	4.9	22.65	2.79	80	8.5	68		
St. Helena .....	1015.1	+0.3	72	51	63.3	56.7	60.0	-1.5	94	9.3	33.86	..	198	..	..		
Freetown, Sierra Leone	1013.3	+1.9	91	67	85.1	73.7	79.3	-1.4	83	6.3	132.30	-24.93	185	..	..		
Lagos, Nigeria .....	1011.7	+0.9	92	68	85.3	74.9	80.1	-0.6	83	7.7	48.09	-23.89	110	5.6	47		
Kaduna, Nigeria .....	1012.6	-1.0	102	48	88.9	..	..	..	66	5.7	46.02	-7.81	94	7.3	61		
Zomba, Nyasaland .....	1011.7	-0.6	93	44	79.5	59.9	69.7	+0.3	69	5.3	39.09	-15.45	91	..	..		
Salisbury, Rhodesia .....	1015.0	-0.3	91	32	76.6	53.8	65.2	-0.1	59	4.3	26.77	-4.68	96	7.2	60		
Cape Town .....	1017.3	+0.3	101	39	72.7	55.3	63.9	+1.6	77	4.7	23.70	-1.34	108	..	..		
Johannesburg .....	1015.4	+0.4	89	26	71.7	50.3	61.0	+1.3	51	3.2	21.53	-11.69	96	8.9	75		
Mauritius .....	1016.0	-0.1	90	54	80.1	67.6	73.8	-0.2	72	6.0	58.89	-9.23	256	7.7	64		
Calcutta, Alipore Obsv.	1007.3	-0.3	105	51	88.3	72.3	80.3	+1.5	86	4.6	62.90	-1.42	92*	..	..		
Bombay .....	1008.7	-0.5	96	64	83.4	75.2	81.8	+1.2	78	4.3	73.66	-1.47	..	..	..		
Madras .....	1008.7	-0.1	107	63	89.8	75.1	82.5	-0.6	76	5.3	46.49	-3.07	51*	..	..		
Colombo, Ceylon .....	1010.1	+0.4	94	62	85.8	74.7	80.3	-0.7	78	6.3	123.90	-43.77	197	6.8	56		
Singapore .....	1009.5	-0.0	92	69	86.8	73.9	80.4	-0.5	80	7.0	77.49	-17.63	155	6.0	49		
Hongkong .....	1013.0	+0.5	91	43	76.8	68.8	72.8	+0.5	75	7.1	91.47	-5.74	133	5.1	43		
Sandakan .....	..	..	94	70	86.9	74.9	80.9	-0.4	84	..	139.57	-14.78	203	..	..		
Sydney, N.S.W. ....	1015.6	-0.3	106	36	70.7	56.0	63.4	+0.3	82	6.0	37.47	-10.01	146	6.8	56		
Melbourne .....	1016.2	-0.1	109	33	66.8	49.3	58.1	-0.3	71	6.9	31.08	-3.61	179	4.8	39		
Adelaide .....	1016.9	-0.1	110	37	72.1	53.0	62.6	-0.4	54	6.1	25.04	-3.86	141	6.4	52		
Perth, W. Australia .....	1016.9	+0.5	106	38	73.7	55.9	64.8	+0.6	61	4.7	39.40	-5.03	121	8.0	65		
Coolgardie .....	1016.0	+0.1	112	31	77.4	51.7	64.5	-0.0	54	3.4	10.74	-0.47	58	..	..		
Brisbane .....	1016.1	+0.2	99	41	77.8	60.2	69.0	+0.1	62	4.9	24.79	-20.50	97	8.1	67		
Hobart, Tasmania .....	1013.1	+0.6	93	32	61.7	46.9	54.3	-0.1	67	6.6	30.29	-6.50	156	5.6	45		
Wellington, N.Z. ....	1016.2	+1.5	77	32	58.7	47.6	53.1	-2.2	76	6.9	38.87	-9.17	147	5.6	46		
Suva, Fiji .....	1011.3	-0.0	90	65	83.3	72.7	77.9	+0.9	81	7.0	121.69	-4.55	258	5.1	42		
Apia, Samoa .....	1009.7	-0.6	90	66	85.4	74.4	79.9	+1.4	77	5.5	123.94	-14.28	202	7.1	59		
Kingston, Jamaica .....	1012.6	-1.1	94	64	87.5	71.6	79.6	+0.3	81	4.4	21.95	-11.64	87	7.6	63		
Grenada, W.I. ....	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..		
Toronto .....	1015.8	-0.8	95	2	55.2	40.3	47.7	+2.5	75	5.6	30.70	-0.58	116	5.6	44		
Winnipeg .....	1016.3	+0.1	92	-34	45.8	26.0	35.9	+1.3	..	5.1	19.76	-7.43	60	..	..		
St. John, N.B. ....	1014.1	-0.5	81	-4	50.3	35.4	42.8	+1.6	78	6.1	41.94	-6.14	144	..	..		
Victoria, B.C. ....	1017.4	+0.7	88	16	55.0	44.2	49.6	+0.2	82	6.3	33.83	-3.52	152	5.9	45		

\* For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen.

(continued from page 128)

	Total	Diff. from normal		Total	Diff. from normal
	(hrs.)	(hrs.)		(hrs.)	(hrs.)
Stornoway	188	+ 3	Liverpool	149	—50
Aberdeen	125	—62	Ross-on-Wyo	180	—43
Dublin	147	—58	Falmouth	199	—32
Birr Castle	147	—35	Gorleston	195	—30
Valentia	158	—45	Kew	173	—28

The special message from Brazil states that the rainfall in the northern regions was very scarce with 2.13 in. below normal, and in the central and southern regions scarce with 0.71 in. and 0.79 in. below normal respectively. Four anticyclones crossed the country and excessive cold was experienced in the south. The weather conditions were good for the gathering of the coffee, cotton, tobacco and cereal crops. At Rio de Janeiro pressure was 1.9 mb. above normal and temperature 1.1°F. below normal.

*Miscellaneous notes on weather abroad culled from various sources.*

"Red rain" lasting generally 10 to 15 minutes but long enough to colour trees, housetops and roads a roddish yellow occurred in northern Italy on the 3rd and 4th. A cloudburst occurred in the Upper Allgäu, Germany, on the 4th. Snow fell in Switzerland down to a level of 4,000 ft. before the 12th, and Alpine passes opened to vehicles were again blocked—at 6,000 ft. the snow was over 3 ft. deep. Navigation reopened at Uleaborg on the 23rd. May, 1933, was the wettest May in Bavaria since records began 86 years ago; the rainfall at Munich was 9.8 in. compared with an average of 3.6 in. (*The Times*, May 6th—June 5th.)

A cloudburst in the Puniwhakau district, 27 miles east of Stratford, New Zealand, about the 7th, devastated hundreds of acres of farm land and obliterated roads and bridges. (*Morning Post*, May 8th.)

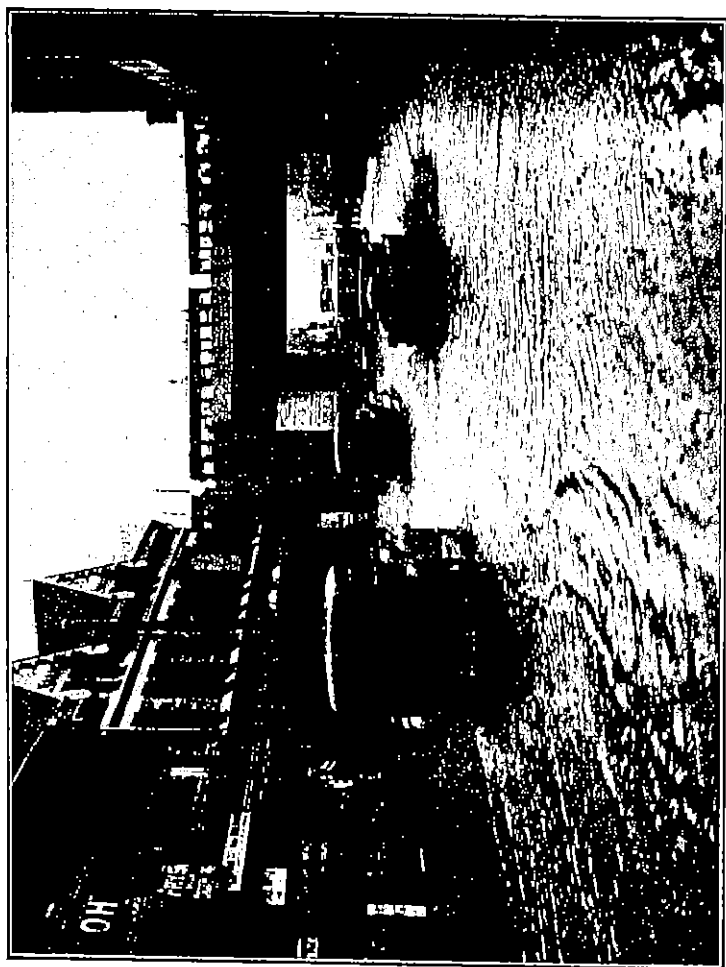
Twenty-one persons were killed in a tornado which swept over western Alabama on the 5th. (*The Times*, May 6th.)

Reports from Canada show that the weather at the beginning of the month there was generally fair, cool and somewhat windy. Except for the Gulf States the temperature over the United States was below normal during the first week of the month, becoming above normal in the following week in the eastern States and after the middle of the month in the Middle States, but remaining below normal throughout along the Pacific Coast. Rainfall was generally in excess at the beginning of the month but deficient later on. (*The Times*, May 8th, and *Washington, D.C.*, U.S. Dept. Agric., *Weekly Weather and Crop Bulletin*.)

### General Rainfall for May, 1933

England and Wales	...	97	} per cent of the average 1881-1915.
Scotland ...	...	89	
Ireland ...	...	114	
British Isles	...	94	





THE SCENE AT SEAFORTH BRIDGE. THE MAIN SOUTHPORT ROAD (SEEN ABOVE) WAS FLOODED FOR A CONSIDERABLE DISTANCE (see p. 132).

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## The Thunderstorms of June, 1933

June in England was remarkable for the persistence of thunderstorm conditions through the greater part of the month. Taking as a basis the stations for which data are published in the *Daily Weather Report*, thunderstorm or thunder heard was reported on no fewer than 17 days, including every day from the 14th to the 26th inclusive, while lightning without audible thunder was reported on several other days.

A sketch of the distribution over the country of days with thunder heard is shown in Fig. 1. This is necessarily rough as it had to be drawn on July 1st when the material available was scanty, but it suffices to show two main areas of frequency, one over London and west-south-westwards to Hampshire (Greenwich 6, South Farnborough 7, Winchester 6), and the other over the Midlands (Birmingham 8, Cranwell 6, Ross-on-Wye 6). From Lutterworth in this area Mr. M. W. Binns wrote on June 22nd: "Twelve thunderstorms have been experienced within a radius of six miles, several passing over Lutterworth, within the last ten days."

June opened with an anticyclone over western Europe and a shallow depression over the eastern North Atlantic. The British Isles lay in the course of a southerly or south-easterly current and temperatures mounted rapidly, but thunderstorms developed only on the south-west coast and in the Channel on the 3rd.

under the influence of a secondary depression over the Bay of Biscay. Subsequently the anticyclone extended over the British Isles, and on the 8th the centre lay to the west of Ireland, with a northerly current over England. Storms developed on this day in the north-west and Midlands. In Buxton, according to the *Daily Dispatch*, a violent storm broke shortly after 4 p.m., an inch of rain falling in a short time. The wooden blocks

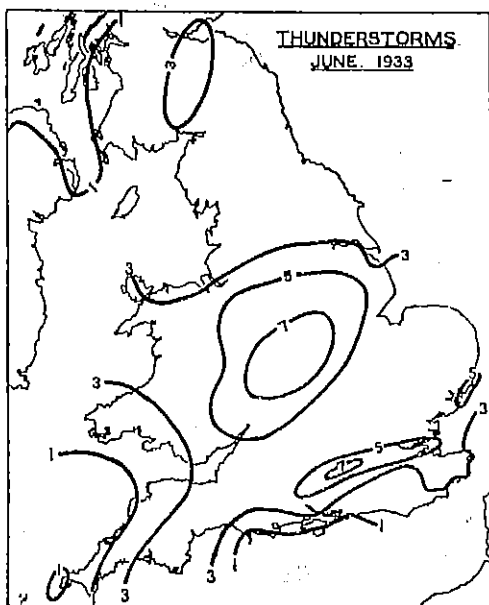


FIG. 1.

of two main roads swelled up and burst. In Manchester, according to the *Manchester Guardian*, the storms began about 3.15 p.m. and continued for three-quarters of an hour with violent rain. Houses were struck and set on fire or otherwise damaged, while several tramway standards were destroyed, the fuse-boxes being melted. In one case the heat developed was so great that the metal of the standard itself became half molten, causing the upper part to bend over. In Kingsway the water was 18 inches deep. Two occupied telephone booths were said to have been struck, and in one case the occupant was thrown into the road, but there were no serious injuries associated with the storm.

With a similar pressure distribution there were storms in a few places on the 9th and 11th. On the 12th pressure became more uniform; isolated storms developed on the 14th and became more numerous on the 15th, when the London area was struck. During a storm on the latter day at Orvington Rectory, Hants., 2.37 in. of rain fell in an hour. On the 16th the British Isles came under the influence of a deep depression over the Faroes and a series of violent storms occurred on the 17th, especially in the Midlands, east and south-east England. At Ipswich 0.52 in. of rain and hail fell in less than half an hour, and slight flooding occurred. Snow was reported on this day at Giggleswick, in Yorkshire, W.R., and at Bellingham, in Northumberland. On the 18th and 19th the depression passed across England, and in its rear on the 19th

thunderstorms developed over the greater part of the country, including London. In Epping Forest two men were killed and two injured among the trees, and a man was killed and another injured at Woolwich while running for shelter. Several houses were also damaged. Hail caused damage to fruit trees in Kent; in some places the hailstones lay four inches deep. At Foxbury House a large fir was shattered by lightning, parts of the trunk being thrown nearly a hundred yards.

The storms continued on the 20th, the most noteworthy being a "cloudburst" at Bootle, a description of which by Mr. H. J. Bigelstone follows this general account. On the 21st a new depression developed over England, and the Midlands and Wales again suffered. Two youths sheltering under a tree near Port Talbot were injured by lightning. At Garstang, in sunny calm weather, large quantities of new-cut hay were seen floating about in the sky, probably as the result of a whirlwind in the neighbourhood. As the depression filled up and passed away storms were again general on the 22nd, especially in south-east England and the Midlands. Many buildings were damaged, and three men were killed. Two of these were sheltering under trees; the third was near an iron railing. A waterspout was said to have occurred near Folkestone, with heavy rain and hail. The main Canterbury-Folkestone road was flooded to a depth of over a foot, while the wooden paving was forced up and cellars were flooded at Dartford in Kent. Another man was killed under a poplar tree in Gloucester.

On the 23rd, 24th and 25th, the pressure distribution over England was nearly uniform, and the storms were more scattered, though London was visited again on the 24th. On the 26th an anticyclone approached from the Atlantic, and a final series of storms developed in south-east England and the Midlands. After this the high pressure spread across the British Isles and fine weather set in and continued to the end of the month.

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## Thunderstorm on Merseyside, June 20th, 1933

By H. J. BIGELSTONE,

*Principal Assistant, Liverpool Observatory and Tidal Institute.*

During the week of June 18-24th the Merseyside area experienced a number of thunderstorms of which one, on the afternoon of June 20th, is stated to have been the worst ever experienced in the area since 1918. The storm appears to have travelled from North Wales passing over Birkenhead and Wallasey, and finally over Liverpool, in the Bootle, Litherland and Seaforth districts where its greatest violence was reached.



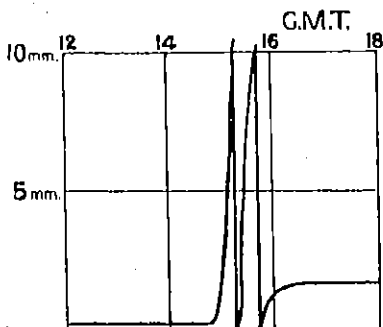
At the Liverpool Observatory, Bidston, thunder was first heard from a southerly direction at 3.12 p.m., followed by vivid flashes of lightning and a torrential downpour of rain. Between 3.45 and 4.45 p.m., 23mm. (0.90in.) of rain were recorded. The wind backed from NW. to WSW. at 3.45 p.m., freshened in a slight squall, and then fell to a calm. A fall in temperature of  $12^{\circ}$  occurred between 3 p.m. and 4.30 p.m. The storm appeared to be directly overhead at 4 p.m. and was followed by a second and less intense storm. Thunder was last heard at 5.30 p.m.

At Corwen, in North Wales, the rain, described as terrific, preceded a storm of hailstones like marbles, and a pronounced drop in temperature was reported. Streets were flooded for some time, due to drains being choked by loose gravel washed through the grids by surface water.

No hail was reported at Bidston, but within an area of less than one mile from the Observatory curious freak occurrences were reported. In Birkenhead one of the main thoroughfares was completely dry, while adjacent streets were flooded. Two houses a mile apart were struck by lightning, almost at the same moment, and by a coincidence the occupiers of the two houses were related. During the storm the control box of a Birkenhead tramcar was fused, the driver receiving slight burns but remaining in control of the car, which was temporarily out of commission. At the Observatory, although there was no actual evidence of lightning striking, light fuses were blown and a telephone switchboard coil was burnt out.

In Wallasey the promenade and main streets were heavily flooded and at least one house was struck by lightning. A residence in West Kirby was also struck. The central part of Liverpool escaped with little more than a shower, and in Wavertree and the south end of the city there was very little rain. In Bootle and Seaforth the violence of the storm and the widespread devastation caused by the floods were such that the scenes on the Birkenhead side of the river were dwarfed into insignificance.

The greatest severity of the storm was confined to a small area of Bootle, only a few feet above sea level and surrounding



Record of rainfall at Liverpool (Bidston) on the afternoon of June 20th.

Violet Street, Akenside Street and Irvine Street. A resident of one of these streets described the floods as descending in a solid wall of water several feet in height from the surrounding higher ground. In Akenside Street, Bootle, the water reached a depth of over 10ft. swirling and eddying down a steep slope and sweeping under a railway bridge. A youth who was trapped by the waters at this point was swept from his cycle, carried away by the torrent and drowned. His body was only recovered after prolonged dragging operations by the police. A second fatality was directly due to the storm, an elderly man hurrying to shelter collapsing and dying from heart failure. People in the Akenside Street area stated that the sky went inky black, and after violent claps of thunder and vivid lightning flashes, the district was lashed by storms of rain and hail, the hailstones being described as being as large as small hens' eggs. An observer, recently home from India, describing the cloudburst, said: "It was without exaggeration typical of an Indian monsoon. A rapid series of lightning flashes and thunderclaps was followed by the cloudburst, the rain being as torrential as in the Punjab."

Local traffic in the Seaforth-Bootle area was entirely disorganised. Motor cars were stranded in attempting a passage, and passengers were confined to the L.M.S. Seaforth station. From Bridge Street to Seaforth Road, Litherland, shops were flooded to a depth of several feet. Pedestrians were transported across the road on handcarts, and a cyclist attempting to cross was thrown into water up to his waist. And this was two hours after the full force of the storm.

The water had not subsided in the flooded area until far into the night. When it had gone down it was found that it had coated everything below the level it had reached with thick evil-smelling slime. Throughout the night inhabitants in the stricken area were hard at work cleansing their houses and the adjoining streets, and striving to win back order from the chaos created by the storm.

On the evening of June 19th a waterspout was observed in the Liverpool area. The phenomenon was first seen at about 7 p.m. (B.S.T.) moving in a north-westerly direction from the Welsh coast across the estuary of the River Mersey. It was not observed on the Birkenhead side of the river, but in the neighbourhood of Waterloo and Blundellsands it was reported as a remarkable spectacle.

From spectators' reports, the waterspout was in the form of a black column, nearly 300ft. in height, depending from a low bank of dense and threatening cloud. The whole scene appeared ominous and forbidding. The column was described as moving obliquely along the water towards the north-east. Other observers

spoke of the column as being conical in shape and of such a density as to appear almost solid. No shipping was seen in the path of the disturbance, which finally passed over the land a little to the north of Waterloo. Shortly after it was lost to view a violent storm of rain swept the district. The whole occurrence lasted a little over half an hour.

## Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, June 21st, in the Society's Rooms at 49, Cromwell Road, South Kensington, Prof. S. Chapman, F.R.S., President, in the Chair.

The President announced that the Council had decided to recommend to a Special General Meeting of Fellows the adoption of revised by-laws, whereby the annual subscription would become two guineas as from January 1st, 1934, instead of three guineas as at present. The President explained that this action had become possible through the introduction of a number of economies, which it was considered did not impair the efficient working of the Society. It was hoped that as a result there would be an increasing number of new Fellows.

Sir Gilbert Walker, C.S.I., F.R.S., gave an informal talk on "Air Cells" in which he brought forward further evidence relating to the formation of clouds.

*O. F. T. Roberts, M.A.—The functional equation of eddy-diffusion (Memoir No. 37).*

From the hypothesis that the density distribution due to scattering satisfies a functional equation expressing uniformity of scattering power, it is shown that the square of the standard deviation of matter scattered from a plane source varies as the time. The method used to get this is extended so as to obtain the density distribution in a series of hermite polynomials, exhibiting directly the manner in which the distribution may differ from that due to the assumption of eddy scatter analogous to thermal diffusion in a solid. The infinite differential equation corresponding to the functional equation is obtained; and the similar result for homogeneous scattering in three dimensions is derived and extended to scatter from a fixed point or line into a medium with uniform mean flow.

*E. L. Hawke, M.A.—Extreme diurnal ranges of air temperature in the British Isles.*

For reasons well understood, the greatest extremes of heat and cold are normally found at the bottom of valleys. Doubtless owing to the prevalent belief that such situations are damp and unhealthy, too few valley meteorological stations have as yet been established in this country to enable us to set an approximate limit for the range of temperature that may occur in a

single day. A diurnal variation over  $40^{\circ}\text{F.}$  has been registered at Greenwich Observatory only ten times since 1841, and is usually regarded as exceptional anywhere in Britain. Yet records begun four years ago in a Hertfordshire valley characterised by a markedly "continental" climate already include 17 instances of a daily range exceeding  $40^{\circ}\text{F.}$ , with  $48^{\circ}\text{F.}$ , on March 28th, 1933, as the outstanding example. It is inferred that places so circumstanced are occasionally subjected to fluctuations of temperature amounting to more than  $50^{\circ}\text{F.}$  within a few hours.

## Correspondence

To the Editor, *The Meteorological Magazine*.

### The Colour of Moonlight

In the June issue of *Hemel en Dampkring* I have discussed the question raised in the *Meteorological Magazine*,\* why moonlight appears blue in a general way. The following notes, which have been submitted to a specialist on these matters, Dr. Minnaert of Utrecht University, and corrected by him, summarise my conclusions.

According to Dr. Minnaert the phenomenon described by Purkinje (the apparent ascendancy in brightness of the blue side of the spectrum over the regions of longer wave-length in mitigated light) has nothing to do with the apparent colour of the illumination of a landscape by the entire band of visible wave-lengths, however weakened that mixture of colours may be. Apart from this the blue colour of a moonlit landscape may be ascribed to five factors, four of which are unimportant from a meteorological point of view:—

1. The scattering of rays in the lowest layer of the atmosphere, containing dust particles, etc., especially during times of well-defined ground inversions, causes a kind of cigarette-smoke veil contributing much to the blue aspect. Dr. Minnaert does not entirely agree with this statement, so I mention it for what it is worth.

2. As soon as artificial sources of light are contrasted with moonlight, there is a tendency on the observer's part to regard the former as white, and the latter as "Air Force blue" in consequence.

3. The colour-distinguishing faculty of the human eye is considerably lessened in circumstances corresponding to the average moonlight intensity. All bright colours are simply struck out of the picture.

4. In regarding a moonlit landscape, the observer's attention is not deflected by landscape details, these being generally invisible in the semi-darkness. Therefore his range of vision

\* See *Meteorological Magazine*, 67, 1932, pp. 294, 254, 256, 284; 68, 1933, p. 9.

contains about three-quarters of clear sky undoubtedly coloured blue by Rayleigh scattering, and a bluish average is the result.

5. There exists a tendency of the human eye, or perhaps I should say of the human mind, to associate blue with darkness and cold, and on the contrary yellow or red with bright things and warmth.

J. C. M. KRUISINGA.

*Nederlandsche Vereeniging Voor Weenen Sterrenkunde, Vriczonveen, Holland.  
June 8rd, 1933.*

### The Temperature of Rain

I was asked recently by Mr. Brunt if I knew of any records of the temperature of rain. I could not remember any, but in thinking about the question it occurred to me that the temperature of rain will normally be just below that of the wet-bulb thermometer, each water drop acting as a wet bulb during its fall. The drops will, however, usually start with a lower temperature than that of the surface air, and if their starting temperature is also below the surface wet-bulb temperature, the difference between the two values will not be quite eliminated by the time the drop has fallen.

Suppose there were no evaporation: then a water drop falling through an atmosphere with a constant lapse-rate would at time  $t$  be below the temperature of the air by an amount

$$a\beta v \left(1 - e^{-\frac{t}{a}}\right)$$

where

$a$  is the lag-coefficient,

$\beta$  is the lapse-rate,

$v$  the rate of fall,

$t$  the time.

This is on the assumption that the drop starts with the temperature of the air at the level of starting. If there were an initial difference of temperature  $x$  between the drop and its surrounding air, then the difference at any time would be:—

$$a\beta v \left(1 - e^{-\frac{t}{a}}\right) + x e^{-\frac{t}{a}}$$

If we put

$$v = 5 \text{ m./sec.}$$

$$\beta = .01^\circ\text{C. per m.}$$

$$a = 0.3$$

$$a\beta v = .015^\circ\text{C.}$$

After 100 seconds (or a fall of 500 m.)  $e^{-\frac{t}{a}}$  is negligibly small and the constant difference is  $a\beta v$  or  $.015^\circ\text{C.}$

The value of  $a$  chosen is that given by Linke for a mercury thermometer—a rain-drop should have a coefficient of the same

order of magnitude. If one takes de Quervain's generalized formula, quoted by Linke, and applies it to a water-drop, then for a rain-drop 2 mm. in diameter  $\alpha$  is approximately .32,  $v$  being approximately 6 m./sec.

If we take the largest rain-drops of 7 mm. in diameter  $\alpha$  comes out as about 2.0,  $v$  as 8 m./sec.,  $\beta$  as .01, and  $\alpha\beta v$  comes to be very nearly  $0.16^{\circ}\text{C}$ .

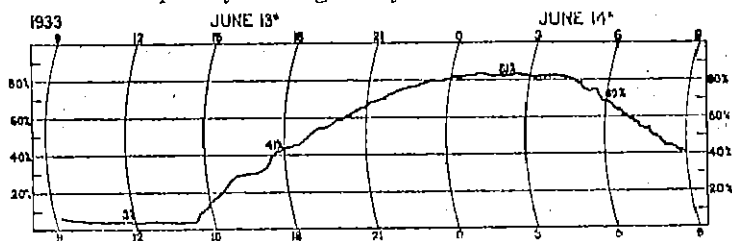
Thus, apart from evaporation, even the largest drops will warm up practically to the air temperature; the net result when evaporation is taken into account will, therefore, be a temperature not very far from the wet-bulb temperature—perhaps a little less than  $0.1^{\circ}\text{C}$ . below it, because in considering the heat balance of the water drop one finds that the effect on evaporation of a rising wet-bulb temperature more than counterbalances the heat required to raise the temperature of the drop.

E. GOLD.

May 31st, 1932.

### Behaviour of the Hair Hygrometer at Heliopolis

In the *Meteorological Magazine* for August, 1930, is published a record from the hair hygrometer at the Meteorological Office, Heliopolis, which exhibits remarkably close agreement with the values of relative humidity computed from readings of the wet and dry-bulb thermometers. The attached copy of the hygrometer for June 13-14th, 1933, from the same instrument unchanged in any detail shows that after three years the accuracy of the instrument is unimpaired, the values of relative humidity over a range from 3 per cent to 81 per cent being in excellent agreement with the values computed from the readings of the wet and dry-bulb thermometers. No special care is taken of the instrument beyond the regular washing of the hairs. The muslin on the wet bulb was changed every three or four days and more frequently during dusty conditions.



Hygrometer at Heliopolis.

It may be of interest to note that the low values of relative humidity were recorded during the highest temperature recorded in the Cairo district since 1869 at least. At Heliopolis the maximum temperature on June 13th, 1933, was  $118^{\circ}\text{F}$ . and at Ismailia the maximum was  $120^{\circ}\text{F}$ . The previous long-period

record of  $115^{\circ}\text{F}$ . had been broken only four days before when the maximum at Heliopolis was  $116^{\circ}\text{F}$ . and at Ismailia  $118^{\circ}\text{F}$ .

J. DURWARD.

*Meteorological Office, R.A.F., Heliopolis. June, 1938.*

### Rates of Rainfall

Recently I had occasion to examine the mean hourly rates of rainfall as published for a number of stations each year in *British Rainfall*, and a few points struck me as worth remark. The figures given below are the mean annual rates derived from the data of the seven years 1925-31:—

*Mean rates of fall.*  
(Inches per hour.)

Lerwick	...	·047	Croydon	...	·052
Renfrew	...	·045	Calshot	...	·052
Aberdeen	...	·045	Falmouth	...	·055
Leuchars	...	·043	Lympne	...	·053
Esksdalemuir	...	·053	Cork	...	·058
Kew	...	·056	Valentia	...	·065

The point of interest here is the relatively high mean rate of fall at the Irish stations, Cork and Valentia, and particularly at the latter. This leads one to inquire as to the behaviour of the mean rate of fall throughout the year. The data for six stations (1925-31) are displayed in graphical form in Fig. 1. In the cases of Lerwick, Aberdeen, Esksdalemuir and Kew the nature of the annual variation is quite definite, a principal

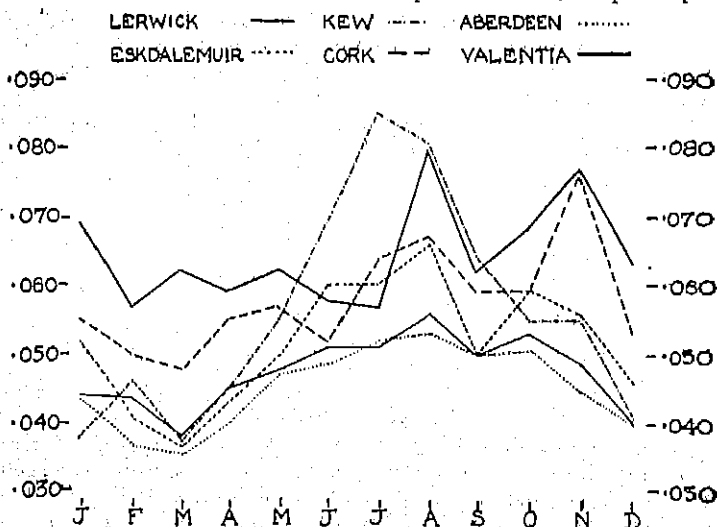


FIG. 1.—Mean rates of rainfall (inches per hour) 1925-31.

minimum in March, a principal maximum in July or August, a secondary minimum in September and a secondary maximum in October or November. When we pass to Cork the same features remain except that the secondary maximum of November has become intensified to be the principal maximum. At Valentia, however, this characteristic annual variation is pretty nearly flattened out, the months February to July and September having nearly the same mean rates, though we are still left with the peaks in August and November. The striking differences therefore as we pass from Scotland or England to the west of Ireland seem to be the vanishing importance of the spring minimum and the increased importance of the November maximum. The comparative uniformity throughout the year in the monthly totals of rainfall in Ireland may perhaps be regarded as supporting the probability of a different sort of annual variation in rate of rainfall.

A. H. R. GOLDIE.

*Edinburgh. June 28th, 1933.*

### **Lightning Discharge during Sunshine**

You may be interested to hear of a curious occurrence here yesterday at 11h. 50m. during a bright interval, when the sun was shining. I was in my kitchen garden when suddenly a flash of lightning seemed to envelop me and simultaneously there was a terrific crash which for a second almost stunned me.

There had been no rain for several hours before the discharge and it did not begin to rain for three-quarters of an hour after the discharge. There had also been no thunder previously in the immediate neighbourhood, nor was there another clap until three-quarters of an hour later, when it also began to rain. A stone chimney stack on one of my outhouses was struck and fell out. I hear to-day that the glass of a car standing in a garage in the village was splintered at the same time.

N. C. REID.

*Caythorpe Hall, Lincolnshire. June 18th, 1933.*

[This letter was forwarded by Dr. W. A. Harwood, who remarks that the peal of thunder and showers in sight were noted at Cranwell.—Ed., *M.M.*]

### **Another Thunderstorm Phenomenon**

With reference to Mr. Ashmore's letter in the June issue, I have made a regular habit of listening in to thunderstorms since 1918. I find that the "lightning" is invariably audible before the flash, in fact it seems to be the case that the discharge tries out various paths before it finally produces the flash.

A. G. W. HOWARD.

*June 21st, 1933.*



### The Thunderstorm of May 6th, 1933

In the article under this heading published in the June issue of this magazine I notice that after my report on the line squall is the remark "the times referred to in this letter are presumably B.S.T." I would respectfully point out that the times referred to are G.M.T.

I regret that I have not access to a map showing the isochrones of the movement of this occlusion, but it is apparent from Mr. Farquharson's article that the occlusion was moving in a north-easterly direction in a line from north-west to south-east across London. Since Waltham Cross is 12 miles north from London and almost on the meridian of Greenwich, it follows that the occlusion must have reached London first.

This is in agreement with the times in my report. The occlusion passed over London at about 16h. 50m. and reached Waltham Cross 30 minutes later at 17h. 20m.

DONALD L. CHAMPION.

187, High Street, Waltham Cross, Herts. July 4th, 1933.

As I indicated in the article under this heading the occlusion was becoming very diffuse by the time it reached London. For this reason it was very difficult to time its arrival at Waltham Cross and I took the observations of Mr. Champion as indicating that arrival. The difference of time would not affect my suggestion that the phenomena described were those associated with the occlusion.

J. S. FARQUHARSON.

### Solar Halo, July 1st, 1933

An unusual solar phenomenon occurred on Saturday, July 1st, when a brilliantly coloured halo of  $46^\circ$  was first noticed at 18h. G.M.T. and remained exceptionally bright until 18h. 25m. when fading commenced; by 18h. 40m. it had practically disappeared. The colouring of the halo was green on the inner edge nearest the sun and blue on the outer edge.

There was no sign of any red on the inside of the halo which is usual in this phenomenon, nor was there any trace of the  $22^\circ$  halo.

At the time visibility was moderately good, there being a surface wind ESE., force 1. Haze was apparent towards the west. The phenomenon was observed in clouds of cirrus and cirro-stratus, and the sun was covered during the latter part of the time by alto-stratus which moved slowly from a north-westerly point, even then the colours in the arc were brilliant.

Over the remainder of the sky there were very fine wisps of cirro-stratus cloud, and towards the north some mare's tails.

E. J. HONREX.

"Colombo," 82, Ceylon Road, Westcliff-on-Sea. July 4th, 1933.

### Vertical Currents Associated with Mammato Clouds

A balloon ascent at Agra at 16h. 35m. I.S.T. on February 19th, 1932, primarily made for the purpose of determining the height of an alto-stratus cloud, throws some light on the physical processes taking place in mammato-cumulus clouds. The purpose of this letter is to give a summary of these observations.

At 8h. on February 19th a "low" associated with a western disturbance which was passing eastwards through Kashmir, was centred over west Central India. A few thunder-showers occurred during the day at Jhansi, Cawnpore, Benares, Allahabad, &c. At Agra there was the usual sequence of clouds associated with the passage of an extra-tropical disturbance and a light shower at 16h. Following this shower, the alto-stratus cloud in south-west and not far from the zenith, developed a festooned structure with a tendency to spread northward. Three minutes before entering the cloud which by then had developed a clear mammato structure, the vertical angle of the balloon was found to increase so rapidly that the tangent screw controlling this movement had to be unclamped and the theodolite manipulated by hand. After a few seconds the balloon became stationary and then moved horizontally for about ten or fifteen seconds. Thereafter the vertical angle was found to decrease rapidly. This series of changes was found to be repeated three times before the balloon actually entered the mammato cloud and vanished out of sight.

Although changes in the vertical and horizontal angles are usually interpreted as being due to changes of wind velocity with height, it is difficult to explain such large velocities in opposite directions in two or three heights within a short range, and therefore one feels justified in attributing it to vertical movements in the air. The observation therefore indicates the presence of upward, downward and possibly also horizontal currents of air near the bottom of a mammato-cumulus cloud layer.

Another balloon was sent up immediately after the disappearance of the first balloon. The festooned and the mammato structure of the cloud had by then disappeared and the balloon did not show the phenomena observed during the previous ascent, thus showing that the upward and downward motions experienced by the first balloon were mainly due to the presence of the mammato cloud. The alto-stratus cloud was 3,414 metres above ground as shown by the first ascent and 3,100 metres as shown by the second ascent, indicating a lowering of the base of the cloud. By 17h. 30m. I.S.T. the clouds cleared away. It may be mentioned here that mammato clouds are often observed at Agra during the passage of western disturbances and they have been found short-lived.

It has been observed that if instability is produced as a result of density distribution in a thin layer of fluid, the latter breaks up into polygonal cells, there being upward motion at the centre of each cell and descending motion at the common boundary of the various neighbouring cells. According to Dr. Simpson,\* after the passage of a thunderstorm there exist in the atmosphere conditions which are markedly favourable for the setting up of such an instability, and if the formation of mammato clouds is due to the same type of instability, one should naturally expect ascending and descending currents in them. The present observations clearly support the above view of the structure and formation of mammato clouds.

KRISHNA CHANDRA.

Upper Air Observatory, Agra, India. January 23rd, 1933.

### Atmospheric Circulation over Tropical Africa

The advent of air services to Africa has given meteorology a fresh impetus, and the *Geophysical Memoir* dealing with the atmospheric circulation over tropical Africa has appeared at an opportune moment. It is bound to be appreciated by those who are interested in African meteorology, as it provides a basis for the study both of the general problem and of the climates of smaller areas.

Scarcity of reliable information, and lack of accurate altitudes, must have rendered the work extremely difficult, and, knowing this, one is loath to criticise. The following points may, however, be of interest.

The altitudes of stations in Southern Rhodesia are now satisfactorily determined; the pressure normals checked, and the old barometers have been standardised against new instruments, and we are in a position to say that the pressures shown in the memoir for this area are some three millibars low.

With regard to the map showing air movements for January, the following suggestions are offered:—

There seems to be no evidence and no justification for bringing the Egyptian air stream 3,500 miles down the axis of Africa. Apart from the time which such a stream would take to accomplish the journey over a region where the winds are mostly light, one would expect the stream of air to be dry. The northerly winds, however, bring abundant moisture to north-west Rhodesia and Bechuanaland, and a dry northerly wind is unknown in Southern Rhodesia once the rainy season has commenced.

It seems more reasonable to make the southernmost limit of the Egyptian steam coincide with the kink in the four-inch isohyet, about latitude  $3^{\circ}\text{S}$ ., longitude  $29^{\circ}\text{E}$ . It is more probable that the part of the south-west monsoon crossing the west coast between the equator and latitude  $10^{\circ}\text{S}$ ., turns south-eastward

\* G. O. Simpson, *Nature*, Vol. 118, 1924, p. 82.

and spreads over the Belgian Congo and north-west Rhodesia, while the part crossing between  $10^{\circ}$  and  $15^{\circ}$ S. latitude enters the Kalahari desert, and, being drier, gives less rain. This current also enters Southern Rhodesia when pressure is low.

The SE. trade of the Indian Ocean which enters South Africa in the east, turns southward on the western side of the Drakensberg Mountains, and mixing with air from the north-east monsoon and the eastern edge of the Kalahari current passes through the Orange Free State to the north of Cape Province. The area traversed by this mixed current is noted for violent thunderstorms. The SE. trade is often entirely displaced by the passage of a low up the south-east coast. At other times it is strengthened by a high pressure on the south-east coast, and at such times it may cover the whole of Southern Rhodesia.

In Southern Rhodesia a steady E. wind is associated with fair weather, a steady NE. wind with thunder-showers and NW. winds with rain periods. Sometimes the NW. current appears above a NE. wind. This gives rain and a marked amount of frontal activity. Fronts also occur when a NE. or NW. current is displaced by the SE. trade. Rhodesia is frequently the battleground of these currents, and a knowledge of their origin and life-history is, therefore, important to meteorologists in these parts.

J. S. PEAKE.

*Meteorological Office, Salisbury, Southern Rhodesia. April 10th, 1938.*

We welcome Mr. Peake's letter. As he says, the work of preparing the memoir in question was exceedingly difficult, and many questions remain which can only be settled by more exact local knowledge than was available to us in London. In fact, the memoir originated in an attempt to clear up a jungle of conflicting data about central Africa.

The addition of about 3 mb. to the mean pressures over Southern Rhodesia, however, introduces a number of new difficulties. For example, it involves us in the alternative that either the pressure (or height) of Pretoria and Johannesburg must be incorrect or that a wedge of high pressure points north-eastward into the interior of Africa across Southern Rhodesia. It would also give a rather steep pressure gradient between Salisbury (Rhodesia) and Zomba (Nyasaland), the height of which has also recently been re-determined by survey. Further material from this part of Africa will be very useful.

The corresponding change in the pressure map for January would in fact not make much difference in the source of the air reaching the greater part of Southern Rhodesia in that month, which is shown in our maps as the southern Indian Ocean. The Egyptian stream is drawn further east, but the fact that it crosses the rainy region of the upper Congo is admittedly a

difficulty, and the source of this rainfall would be more obvious if the air over the whole of this moist region could be derived from the equatorial Indian Ocean.

We naturally did not suppose that the "fronts" shown in the memoir were immovable. Successive years, and even a single season, can be expected to show wide swings. We attempted to show only the simplest outlines, while the details must be filled in by the meteorologists on the spot. From Mr. Peake's last two paragraphs there appears to be as much scope for the definition of air masses of different origin in central Africa as there was in Europe.

C. E. P. BROOKS.

S. T. A. MURLENS.

## NOTES AND QUERIES

### High Pilot-Balloon Ascents at Shoeburyness

On Thursday, June 15th, 1933, a very high double-theodolite pilot-balloon ascent was made at Shoeburyness. This ascent was commenced at 08.10 and a height of 57,000 feet was secured in 53 minutes. The balloon then burst, a very unfortunate occurrence, as it was still rising strongly and the visibility was remarkably good. This ascent is a two-theodolite record for the station, easily surpassing the previous record of 52,000 feet set up on June 4th, 1925.

The balloon used was a 750-gram one by Pirelli. It was given a free lift of 910 grams and was unloaded. Its mean rate of ascent over the first 10 minutes was 1,260 feet per minute. The results of the ascent indicated a light wind from a north or north-easterly point up to the maximum height attained.

At 18.15 on the same day a further ascent was made with a similar balloon. A free lift of 680 grams was given and the mean rate of ascent secured was 830 feet per minute during the first ten minutes of flight. The balloon attained a height of 42,000 feet in 55 minutes. It burst at this point, unfortunately. Visibility was good and the balloon could have been held in both theodolites for a considerable time longer. A fairly steady current throughout from a north-westerly point was found.

C. E. BRITTON.

### The Secular Variation of Temperature at Spitsbergen

The deviations of temperature from normal at Green Harbour, Spitsbergen, quoted in the monthly article on "Weather of the Month," have in the last few years shown some astounding positive values which seemed to require investigation. The data available consist of monthly means at 8h. local time for the period December, 1911, to August, 1930, extracted from the year books of the Norwegian Meteorological Institute, and for

the remainder of the period to February, 1933, corresponding values computed from the daily figures in the British *Daily Weather Report*.

The annual means (Table 1) show apparently an eleven-year cycle superposed on a steady rise.

Table 1.—Mean Annual Temperature at Spitsbergen, 8h. °F.

	0	1	2	3	4	5	6	7	8	9
1910	—	—	13.8	18.7	16.2	14.7	13.0	9.1	13.3	16.7
1920	22.3	18.2	22.5	23.5	22.6	21.6	19.4	18.3	19.2	16.9
1930	22.8	25.1	22.3							

Taking the three variables:—

$T$  = mean annual temperature (°F.)

$t$  = time in years from 1911

$s$  = square root of sunspot number\*

we find the partial correlation coefficient between temperature and time to be +.79, and that between temperature and square root of sunspot number = .66. The regression equation is

$$T = 18.1^{\circ}\text{F.} + 0.49t - 0.75s.$$

The sunspot minima of 1913 and 1923 both coincide with maxima in the curve of mean annual temperatures; the pronounced sunspot maximum of 1917 corresponds with a pronounced minimum of temperature, but the temperature minimum of 1929 comes one year later than the corresponding sunspot maximum which, however, was not well marked.

The most remarkable features of the period are the extraordinarily low temperatures during the winter of 1916-7, the mean for November to April being  $-11.4^{\circ}\text{F.}$  and the mean for February  $-21.0^{\circ}\text{F.}$ , and the mildness of the winter of 1930-1, the mean for November to April being  $+16.5^{\circ}\text{F.}$  and that for December, 1930,  $+23.1^{\circ}\text{F.}$

It is well known that there is a positive relation between the amount of ice in Arctic waters and the number of sunspots, and the temperature variations at Spitsbergen appear to show another aspect of this relationship. The secular rise may be related to the remarkable secular rise of winter temperatures in western Europe, to which attention has repeatedly been drawn in recent years.

C. E. P. Brooks.

### Meteorology in the Smithsonian Report

On December 18th, 1931, the United States "Research Corporation" presented grants and commemorative medals to Dr. A. E. Douglass for his work on tree-growth and rainfall, and to Dr. E. Antevs for his work on the chronology of the late Ice Age in America. An account of the ceremony of presentation is given in the Smithsonian Report for 1931, including interesting summaries of the present state of their researches by

\*See London, *Q.J.R. Meteor. Soc.* 53, 1927, p. 68.

Douglass and Antevs. Other papers in the same volume describe the results of "Twenty-five years' study of solar radiation," by Dr. C. G. Abbot, and "Sun spots and radio reception," by H. T. Stetson.

## Reviews

*Grundbegriffe der Wetteranalyse.* By Gustav Swoboda. Sammlung Gemeinnütziger Vorträge No. 641/644. Prague, 1932.

This little book gives in very readable form and with a wealth of illustration an account of the origin of the polar front theory of cyclones and of the most recent developments of that theory. Commencing with a general account of cyclones and anticyclones, Dr. Swoboda goes on to describe the life history of an ideal cyclone, cyclone families and the structure of anticyclones, the descriptions being three-dimensional and carried up into the stratosphere. Thus, for example, the slowing up of an occluded cyclone is explained as due to the extension of cyclonic motion to the cirrus level. The third section defines polar and tropical air and their characteristics, and the fourth describes how the interaction of these air masses brings about the phenomena of cyclone families, regeneration and fronts; there is also an important sub-section on the importance of humidity. The last section shows how the polar front theory throws new light on the general circulation of the atmosphere and its seasonal and periodic changes, the work of Bergeron on "dynamic climatology" being fully described. Then comes a two-page table giving in detail the characteristics of masses of different origin. There are no fewer than 27 illustrations, each with a full explanation.

*L'Influence Solaire et les Progrès de la Météorologie.* Henri Mémery. Observatoire de Talence. 1932.

M. Mémery continues his investigations into what may be termed the small-scale relations between solar and terrestrial phenomena, tracing the effect of individual sunspots on the weather of individual days. In this paper he adopts a new method; daily averages of the average sunspot numbers over a series of years give a markedly irregular curve of annual variation, and the irregularities are compared with those of the annual variation of temperature, rainfall and earthquakes. The curves are at first glance striking, but the fit of the details is not always as good as might be desired, and it is not unlikely that a careful statistical discussion might show that the apparent agreements may be merely coincidences. The reviewer also finds difficulty in accepting the idea of the regular annual recurrence of fluctuations of solar activity.

### Books Received

*Report on rainfall registration in Mysore for 1930 and for 1931.*

By C. Seshachar, Bangalore, 1931 and 1932.

*Meteorology in Mysore for 1930 and 1931*, being the results of observations at Bangalore, Mysore, Hassan, Chitaldrug, Balehonmuri and Jogimatti. Thirty-eighth and thirty-ninth Annual Reports, Bangalore, 1931 and 1932.

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### News in Brief

Col. Sir Henry Lyons, F.R.S., Director of the Science Museum, has been elected President of the Institute of Physics for the session 1933-4.

Prof. Vilhelm F. K. Bjerknes of the Physical Institute of the University of Oslo was elected a foreign member of the Royal Society at the meeting held on May 26th, 1933.

Sir Richard Gregory, Editor of *Nature* and President of the Royal Meteorological Society, 1928-30, has been elected a Fellow of the Royal Society.

The Howard Prize of the Royal Meteorological Society has been awarded to Cadet J. S. Robertson of H.M.S. Training Ship *Conway* for the best essay on "Visibility and fog."

At a meeting of the Society on July 3rd Sir Napier Shaw was elected an Honorary Fellow of the Royal Society of Edinburgh.

It has been announced that Brigadier E. E. B. Mackintosh, D.S.O., will succeed Col. Sir Henry Lyons, F.R.S., as Director of the Science Museum.

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### The Weather of June, 1933

Pressure was below normal over the United States and Canada (except for a region round the Hudson Bay), the south-western part of the North Atlantic, northern Africa including Madeira, and Europe except northern Scandinavia and Russia. The greatest deficits were 5.1mb. at Paris and Helder, 5.3mb. at Zurich and 5.8mb. at Lemberg. Pressure was above normal over Mexico, the Hudson Bay, the central part of the North Atlantic and northern Scandinavia and Russia, the greatest excess being 5.3mb. in the Atlantic at 50°N., 30°W. Temperature was above normal in London, Scandinavia and Spitzbergen, and below normal in central Europe and at Lisbon. Rainfall was below normal in London and parts of Scandinavia and above normal in central Europe, eastern Gothaland and Spitzbergen.



June opened with fine, warm weather in the east of England under the influence of an anticyclone over the Continent, but in the west and south-west weather was unsettled. By the 4th the fine weather had spread over the country and high maximum temperatures were recorded; in many parts of England temperatures of  $85^{\circ}\text{F}$ . and over were reached. Some stations on the east and south coasts, however, did not record these high temperatures, the highest temperature reached at Gorleston during this period was  $67^{\circ}\text{F}$ . In Ireland, also, the high temperatures were not reached. Much sunshine was registered during this period; Croydon had 112.2hrs. from the 1st to the 8th, an average of 14 hours a day; Cambridge had 73.2hrs. in five days and Norwich had 74.9hrs. from the 4th to the 8th, an average of 15 hours a day. By the 9th an anticyclone on the Atlantic extended over the British Isles and gave a current from a northerly direction and temperatures fell generally. Weather was cool until the 13th; on that day rain fell in the east, ending a drought which had lasted in parts of south-east England for 16 days. The 14th and 15th were warm in the south and Midlands. On the 15th a depression moving southwards from Iceland caused rain and a gale in Scotland on the 16th and strong squally winds and cool unsettled weather on the 17th and 18th. Pressure remained low over the British Isles until the 25th; thunderstorms occurred accompanied by heavy rain and sometimes by hail. Whaley Bridge, Cheshire, had 1.86in. on the 18th and Crickhowell, Dan-y-Park, Brecon, 1.56in. on the 24th.

The abnormal frequency of thunderstorms during June is described on pp. 129-31.

The distribution of bright sunshine for the month was as follows:—

	Total	Diff. from		Total	Diff. from
	(hrs.)	normal		(hrs.)	normal
	(hrs.)	(hrs.)		(hrs.)	(hrs.)
Stornoway	202	+24	Liverpool	208	+ 0
Aberdeen	236	+62	Ross-on-Wye	197	0
Dublin	137	-62	Falmouth	238	+17
Blr Castle	139	-25	Gorleston	239	+20
Valentia	139	-49	Kew	259	+62

The special message from Brazil states that rain was scarce in the north, centre and south, the averages being 1.21in. 0.47in. and 1.86in. below normal. Four anticyclones and some active depressions passed across the country. During the last 10 days frost was general in the south. The crops were doing well in the north; but in the centre and south they were affected by the frost and low temperature, especially the tobacco, coffee, cotton and beans. At Rio de Janeiro pressure was 0.7mb. above normal and temperature  $19.8^{\circ}\text{F}$ . below normal.

*Miscellaneous notes on weather abroad culled from various sources.*

On the 2nd exceptionally heavy rain, which afterwards turned to sleet and hail, was reported from Rome; the storm lasted some hours, and when it was over an inch of ice lay on the streets. Serious damage due to heavy storms on the 15th-16th was reported from the area round San Sebastian, houses were flooded, two people were drowned and three others were buried in a landslide. Severe storms also occurred over a large part of France on the 16th-18th, causing damage to crops. Snow fell on the mountains in northern Italy about the middle of the month; heavy rains caused rivers to overflow, the waters in Lake Maggiore rose 6 feet in 48 hours. During a violent storm a waterspout which formed over Lake Varese burst on the shore and let fall a rain of fish. (*Morning Post*, June 3rd; *The Times*, June 19th and 24th.)

The monsoon rains were particularly heavy in Lower Burma at the beginning of the month, and there were extensive floods in the Pegu district. Heavy rain caused damage in Anatolia, floods wrecking a train. Exceptionally high temperatures were reached in Cairo during the first half of June, the record being beaten twice, 116°F. (46.9°C. at Giza) was reached on the 9th and 118°F. (48°C. at Helwan) on the 13th.\* (*The Times*, June 5th and 19th and *Cairo Physical Department, Daily Weather Report*, June 10th and 14th.)

A hurricane accompanied by violent rainstorms struck Trinidad on the night of the 27th, eight lives were lost and hundreds of houses were damaged or destroyed; serious damage was done to the coconut and cocoa plantations. (*The Times*, June 30th and July 5th.) Hurricanes are very rare so far south as Trinidad.

A heat wave lasting about ten days occurred in a large part of the United States during the first part of the month. Many stations recorded 100°F. including Albany, N.Y., and Washington, D.C. High temperatures were also reached in Ontario and Quebec. During the first part of the month weather was generally favourable in Canada for the crops, but in the middle of the month the prairies experienced great heat, which lasted some days, and by the end of the month the crops were suffering from lack of moisture. (*The Times*, June 10th-26th, and *Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin*.)

**General Rainfall for June, 1933**

England and Wales	...	92	} per cent of the average 1881-1915.
Scotland ...	...	86	
Ireland ...	...	94	
British Isles	...	91	

\*See also p. 187.

## Rainfall: June, 1933: England and Wales.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>London</i>	Camden Square .....	1.85	92	<i>Leis.</i>	Thornton Reservoir ...	2.38	110
<i>Kent</i>	Tenterden, Ashenden ...	1.28	67	<i>Leis.</i>	Belvoir Castle .....	2.24	117
"	Folkstone, Boro. San. ...	2.43	...	<i>Leis.</i>	Ridlington .....	2.70	141
"	St. Peter's, Hildersham ...	...	...	<i>Leis.</i>	Boston, Skirbeck .....	2.74	118
"	Eden'hdg., Falconhurst ...	1.03	74	"	Cranwell Aerodrome ...	2.06	122
"	Sevenoaks, Speldhurst ...	1.56	...	"	Skegness, Marine Gdns ...	1.77	98
<i>Sus.</i>	Compton, Compton Ho. ...	2.00	84	"	Louth, Westgate .....	1.87	87
"	Patching Farm .....	3.41	169	"	Brigg, Wrawby St. ...	1.85	...
"	Eastbourne, Wil. Sq. ...	2.33	126	<i>Notts.</i>	Worksop, Hodsock ...	2.13	108
"	Heathfield, Barklye ...	2.08	97	<i>Derby.</i>	Derby, L. M. & S. Rly. ...	1.48	66
<i>Hants.</i>	Vontnor, Roy, Nat. Hos. ...	1.04	57	<i>Derby.</i>	Buxton, Terr. Slopes ...	4.03	144
"	Fordingbridge, Oaklands ...	1.81	98	<i>Derby.</i>	Runcorn, Weston Pt. ...	1.56	60
"	Ovington Rectory .....	5.03	217	<i>Lancs.</i>	Manchester, Whit Pk. ...	3.00	140
"	Sherborne St. John ...	2.06	125	"	Stonyhurst College ...	2.63	82
<i>Herts.</i>	Welwyn Garden City ...	1.83	...	"	Southport, Hankoat Pk ...	1.42	65
<i>Bucks.</i>	Slough, Upton .....	1.47	71	"	Lancaster, Greg Obay. ...	1.67	65
"	H. Wycombe, Blackwell ...	2.00	...	<i>Yorks.</i>	Wath-upon-Deane ...	...	41
<i>Oxf.</i>	Oxford, Mag. College ...	1.22	57	"	Wakefield, Clarence Pk. ...	...	46
<i>Nor.</i>	Misford, Sedgemoor ...	2.14	111	"	Oughtershaw Hall .....	3.00	...
"	Oundle .....	3.10	...	"	Wetherby, Ribston H. ...	1.34	64
<i>Heds.</i>	Woburn, Crawley Mill ...	1.80	90	"	Hull, Pearson Park ...	1.50	77
<i>Cam.</i>	Cambridge, Bot. Gdns. ...	4.86	280	"	Holme-on-Spalding ...	2.00	...
<i>Essex.</i>	Chelmsford, County Lab. ...	1.00	57	"	West Witten, Ivy Ho. ...	2.24	110
"	Lexden Hill House ...	1.88	...	"	Pelxkirk, Mt. St. John ...	1.63	77
<i>Suff.</i>	Haughley House .....	1.80	...	"	York, Museum Gdns. ...	1.59	75
"	Campsea Ash. ....	1.57	88	"	Pickering, Hungate ...	1.06	92
"	Lowestoft Sec. School ...	2.44	135	"	Scarborough .....	1.22	60
"	Bury St. Ed., Westley H. ...	2.02	96	"	Middlesbrough .....	1.62	80
<i>Norfolk</i>	Wells, Holkham Hall ...	1.84	68	"	Bulfordale, Hury Res. ...	1.00	83
<i>Wills.</i>	Dovizes, Higholers .....	1.43	68	<i>Derb.</i>	Ushaw College .....	1.54	71
"	Osno, Castleway .....	2.52	109	<i>Nor.</i>	Newcastle, Town Moor ...	2.16	90
<i>Dor.</i>	Lyons, Melbury Ho. ...	1.53	67	"	Bollingham, Highgreen ...	1.04	84
"	Weymouth, Westham ...	...	21	"	Lilburn Tower Gdns. ...	1.73	84
"	Shaftesbury, Abbey Ho. ...	2.21	96	<i>Cumb.</i>	Carlisle, Scalby Hall ...	2.04	81
<i>Devon.</i>	Plymouth, The Hoe ...	2.12	98	"	Borrowdale, Southwaite ...	4.00	60
"	Holne, Church Pk. Cott. ...	2.50	89	"	Borrowdale, Moraine ...	4.54	...
"	Teignmouth, Den Gdns. ...	2.24	114	"	Keswick, High Hill ...	2.71	93
"	Oullompton .....	1.98	91	<i>West.</i>	Appleby, Castle Bank ...	1.06	85
"	Sidmouth, Sidmouth ...	3.11	148	<i>Mon.</i>	Abergavenny, Larch ...	2.04	121
"	Barnstaple, N. Dev. Ath. ...	1.88	92	<i>Glam.</i>	Yatalyfern, Wern Ho. ...	2.68	71
"	Dartm'r, Oramore Pool ...	2.00	...	"	Cardiff, Ely P. Stn. ...	1.47	69
"	Okohampton, Uplands ...	1.81	66	"	Trerherbert, Tynywaun ...	3.46	...
<i>Corn.</i>	Redruth, Trowleg ...	2.04	82	<i>Carm.</i>	Ormarthen Friary ...	1.98	67
"	Penzance, Morrab Gdn. ...	1.04	87	<i>Pemb.</i>	Haverfordwest, School ...	2.68	90
"	St. Austell, Trevarna ...	3.07	118	<i>Card.</i>	Aberystwyth .....	2.80	...
<i>Soms.</i>	Chewton Mendip .....	1.01	54	<i>Rad.</i>	Birm W.W. Tyrmynydd ...	4.50	189
"	Long Ashton .....	1.10	47	<i>Mont.</i>	Lake Yrmyw. ....	3.50	111
"	Street, Millfield .....	1.93	92	<i>Flint.</i>	Sealand Aerodrome ...	1.32	62
<i>Glos.</i>	Blookley .....	1.52	...	<i>Mer.</i>	Dolgelly, Bontddu ...	5.52	158
"	Gloucester, Gwynfa ...	1.88	56	<i>Carn.</i>	Llandudno .....	1.59	76
<i>Hera.</i>	Ross, Birchles .....	2.15	90	"	Snowdon, L. Llydaw ...	0.85	...
<i>Salop.</i>	Chursh Stretton .....	3.26	135	<i>Ang.</i>	Holyhead, Salt Island ...	1.89	65
"	Shifnal, Hatton Grange ...	2.83	127	"	Lligwy .....	1.68	...
<i>Staffs.</i>	Market Drayton, Old Sp. ...	1.74	72	<i>Isle of Man</i>	Douglas, Boro' Com. ...	2.70	100
<i>Worc.</i>	Omborsley, Holt Lock ...	1.43	68	<i>Guernsey</i>	St. Peter P't. Grange Rd ...	1.64	80
<i>War.</i>	Alcester, Ragley Hall. ...	1.01	84				
"	Birmingham, Edgbaston ...	2.26	97				

## Rainfall: June, 1933: Scotland and Ireland.

Co.	STATION	In.	Per- cent of Av.	Co.	STATION	In.	Per- cent of Av.
<i>Wig.</i>	Pt. William, Monreith	2'50	100	<i>Suth.</i>	Melvieh .....	1'70	88
	New Luce School.....	3'22	111		Loch More, Achfary...	8'00	108
<i>Kirk.</i>	Dalry, Glendarroch ...	2'01	94	<i>Caith.</i>	Wick .....	1'46	81
	Caraphairn, Shiel .....	4'11	108	<i>Ork.</i>	Doornosa .....	1'04	57
<i>Dumf.</i>	Dumfries, Orlerton, R.I.	2'45	108	<i>Shet.</i>	Lerwick .....	'04	53
	Eskdalemuir Obs. ....	2'20	70	<i>Cork.</i>	Calernagh Rectory .....	1'08	...
<i>Roeb.</i>	Branxholm .....	1'20	57		Dunnamway Rectory ..	1'23	35
<i>Selk.</i>	Ettrick Manse .....	'87	24		Cork, University Coll.	1'50	08
<i>Peeb.</i>	West Linton .....	2'12	...		Ballinacorra .....	1'75	07
<i>Berv.</i>	Marchmont House .....	1'00	47	<i>Kerry.</i>	Valentin Obay .....	2'80	80
<i>E. Lo.</i>	North Berwick Res. ....	1'64	93		Gearahameon .....	3'40	08
<i>Midl.</i>	Edinburgh, Roy. Obs.	1'88	94		Killarnoy Asylum .....	...	...
<i>Ian.</i>	Anshtyfordle .....	1'81	...		Darrynane Abbey .....	1'03	61
<i>Ayr.</i>	Kilmarnock, Kay Pk. ...	2'35	...	<i>Wat.</i>	Waterford, Gortmore ..	2'20	86
	Girvan, Pinnore .....	2'05	102	<i>Tip.</i>	Nonagh, Cas. Lough ..	2'00	108
<i>Renf.</i>	Glasgow, Queen's Pk. ...	1'98	80		Roscon, Timoney Park ..	3'72	...
	Greenock, Prospect H. ...	3'09	94		Cashol, Ballinamona ...	2'10	05
<i>Hute.</i>	Rothcary, Ardenoraig. ...	3'05	...	<i>Lim.</i>	Foynes, Coolnanes .....	1'72	37
	Dougarie Lodge .....	2'02	...		Castlecounnel Rec. ....	2'13	...
<i>Arg.</i>	Ardgour House .....	5'80	...	<i>Clare.</i>	Inagh, Mount Callan ...	2'00	...
	Glen Etive .....	3'88	88		Broadford, Hurdlest'n. ...	2'30	...
	Oban .....	3'00	121	<i>Wesf.</i>	Gorey, Courtown Ho. ...	2'03	121
	Poltalloch .....	4'06	136	<i>Kilk.</i>	Kilkenny Castle .....	2'13	88
	Inveraray Castle .....	5'28	139	<i>Wick.</i>	Rathnew, Olanmannon ..	1'07	...
	Islay, Kallabus .....	1'84	70	<i>Carl.</i>	Hacketstown Rectory ..	...	...
	Mull, Benmore .....	2'00	...	<i>Leix.</i>	Blandsfort House .....	2'03	113
	Tiree .....	2'11	83		Mountmellick .....	2'01	...
<i>Kinr.</i>	Loch Leven Sluice .....	1'84	84	<i>Offaly.</i>	Birr Castle .....	2'51	109
<i>Porth.</i>	Loch Dhu .....	3'00	72	<i>Kild'r.</i>	Monasteravin .....	...	...
	Balquhiddar, Stronvar ..	2'40	...	<i>Dublin.</i>	Dublin, FitzWm. Sq. ...	1'25	04
	Orill, Strathearn Hyd. ...	1'52	58		Balbriggan, Ardgillan. ...	1'58	70
	Blair Castle Gardens ...	'78	37	<i>Meath.</i>	Beauparc, St. Cloud ...	2'50	...
<i>Angus.</i>	Kettins School .....	1'34	94		Kells, Headfort .....	2'07	112
	Pearso House .....	1'05	...	<i>W. M.</i>	Moate, Coolators .....	2'80	...
	Montrose, Sunnyside ...	...	...		Mullingar, Belvedere ...	2'77	106
<i>Aber.</i>	Braemar, Bank .....	1'54	70	<i>Long.</i>	Castle Forbes Gdns. ...	3'11	121
	Logie Coldstone Sch. ...	1'28	60	<i>Gul.</i>	Ballynahinch Castle ...	3'78	107
	Aberdeen, King's Coll. ...	'86	50		Galway, Grammar Sch. ...	1'50	...
	Pyvie Castle .....	1'40	67	<i>Mayo.</i>	Mallaranny .....	4'30	...
<i>Moray.</i>	Gordon Castle .....	1'80	88		Westport House .....	2'08	110
	Grantown-on-Spey .....	1'56	69		Delphi Lodge .....	6'09	116
<i>Nairn.</i>	Nairn .....	1'88	104	<i>Sligo.</i>	Marken Obay .....	4'05	138
<i>Inv's.</i>	Ben Alder Lodge .....	2'31	...	<i>Cavan.</i>	Belturbet, Oloverhill ...	2'41	90
	Kingsale, The Birches ...	'08	...	<i>Ferm.</i>	Enniskillen, Portora ...	2'52	...
	Loch Quoich, Loan .....	4'75	...	<i>Arm.</i>	Armagh Obay .....	2'14	85
	Glenquoich .....	3'28	67	<i>Down.</i>	Fofanny Reservoir .....	3'72	...
	Inverness, Culduthel R. ...	2'01	...		Seaford .....	2'85	108
	Arisaig, Faire-na-Sgùir ...	3'07	...		Donaghadee, C. Stn. ...	1'78	76
	Fort William, Glasdrum ...	3'02	...		Banbridge, Milltown ...	2'03	114
	Skye, Dunvogan .....	3'84	...	<i>Antr.</i>	Belfast, Cavohill Rd. ...	3'15	...
	Barra, Skallary .....	3'23	...		Aldergrove Aerodrome ...	2'00	110
<i>R &amp; C.</i>	Alness, Ardross Castle ...	2'03	110		Ballymena, Harryville ...	2'85	98
	Ullapool .....	3'54	150	<i>Lon.</i>	Londonderry, Oreggan ...	3'17	112
	Achnashellach .....	4'30	108	<i>Tyr.</i>	Omagh, Edenfel .....	2'48	86
	Stornoway .....	2'05	88	<i>Don.</i>	Malin Head .....	1'83	...
<i>Suth.</i>	Lairg .....	2'03	97		Millford, The Manse ...	2'70	98
	Tongue .....	1'93	94		Killybegs, Rockmount. ...	3'02	96

## Climatological Table for the British Empire, January, 1933

STATIONS	PRESSURE		TEMPERATURE						PRECIPITATION		BRIGHT SUNSHINE						
	Mean of Day M.S.L.	Diff. from Normal	Absolute		Mean Values				Mean Cloud Am't	Relative Humidity %	Am't from Normal	Diff. from Normal	Days	Hours per day	Per cent- age of possible		
			Max.	Min.	1/2 max. and min.	Diff. from Normal											
							° F.	° C.								° F.	° F.
London, Kew Obsy. . .	1020.8	+ 3.2	53	28	41.5	33.1	37.3	- 1.6	35.4	7.5	88	1.34	0.42	15	1.3	15	
Gibraltar . . . . .	1018.8	- 2.7	66	42	61.6	47.8	54.7	- 0.2	48.4	5.3	86	14.94	+ 10.30	17	..	..	
Malta . . . . .	1014.6	- 2.4	65	43	59.6	49.7	54.7	- 0.6	49.6	6.2	76	6.98	+ 3.77	21	4.9	50	
St. Helena . . . . .	1011.9	- 0.7	72	56	68.0	59.8	63.9	- 0.1	60.9	8.3	93	1.94	..	16	..	..	
Freetown, Sierra Leone . .	1012.8	+ 2.0	98	69	87.2	74.5	80.9	- 0.4	75.5	3.9	90	0.00	- 0.41	0	..	..	
Lagos, Nigeria . . . . .	1009.7	+ 0.1	92	66	87.3	74.6	80.9	- 0.0	74.1	3.8	86	4.98	+ 3.89	3	6.0	51	
Kaduna, Nigeria . . . . .	1011.4	- 3.3	96	54	90.9	61.6	76.3	+ 2.9	53.5	4.2	81	10.86	+ 0.24	1	8.2	71	
Zomba, Nyasaland . . . . .	1007.7	+ 0.3	86	62	78.6	64.7	71.7	- 1.1	67.7	8.6	81	10.86	+ 0.24	24	..	..	
Salisbury, Rhodesia . . . .	1009.0	- 1.6	82	54	76.2	60.2	68.2	- 1.5	63.2	8.1	85	10.18	+ 2.86	20	4.2	32	
Cape Town . . . . .	1012.6	- 0.8	86	55	79.8	60.9	70.3	+ 0.4	60.9	6.2	62	0.68	0.00	3	..	..	
Johannesburg . . . . .	1008.7	- 0.4	90	47	80.1	55.7	67.9	+ 1.2	57.7	4.4	61	2.38	+ 3.79	13	8.9	65	
Mauritius . . . . .	1012.3	+ 0.4	98	67	86.9	72.7	79.8	+ 0.5	75.6	6.4	69	5.22	- 2.54	19	8.7	66	
Calcutta, Alipore Obsy. . .	1015.9	+ 0.7	83	48	76.3	54.2	65.3	- 1.3	54.1	8.2	21	0.78	+ 0.36	2*	..	..	
Bombay . . . . .	1012.9	- 0.7	91	57	85.6	67.5	76.5	+ 1.0	65.8	2.0	73	0.00	- 0.10	0*	..	..	
Madras . . . . .	1013.8	- 0.3	87	65	84.1	69.3	76.7	+ 0.5	71.2	3.2	82	0.00	- 1.14	0*	..	..	
Colombo, Ceylon . . . . .	1010.3	- 0.5	90	68	85.7	73.0	79.3	- 0.2	74.5	6.5	80	6.57	+ 3.32	17	5.1	43	
Singapore . . . . .	1009.6	- 0.8	90	71	85.2	72.5	78.9	- 0.8	75.3	7.0	85	11.02	+ 2.13	22	4.7	39	
Hongkong . . . . .	1021.7	+ 2.0	73	41	60.9	51.5	56.2	- 4.0	50.8	9.0	73	0.48	- 0.84	6	2.4	22	
Sandakan . . . . .	1010.1	..	87	73	85.4	75.1	80.3	+ 0.5	76.4	7.6	82	1.76	- 1.76	21	..	..	
Sydney, N.S.W. . . . .	1009.7	- 2.7	101	55	76.3	65.1	70.7	- 0.9	65.5	7.2	69	6.46	- 2.79	16	6.4	45	
Melbourne . . . . .	1011.2	- 1.7	96	47	76.2	56.1	66.1	- 1.3	58.0	6.0	60	1.74	- 0.15	8	6.2	43	
Adelaide . . . . .	1011.8	- 1.2	103	50	80.3	60.2	70.3	- 3.6	59.5	4.7	72	2.25	+ 1.53	9	7.2	51	
Perth, W. Australia . . . .	1012.1	- 0.4	103	57	83.7	64.9	74.3	+ 0.5	62.4	4.9	47	0.57	+ 0.23	3	10.2	73	
Coorgardie . . . . .	1011.7	+ 0.2	103	50	90.7	60.0	75.3	- 2.1	61.3	4.7	49	0.11	- 0.35	2	..	..	
Brisbane . . . . .	1009.9	- 1.4	94	65	85.9	69.5	77.7	+ 0.5	71.1	6.6	61	10.01	+ 3.51	14	8.9	65	
Hobart, Tasmania . . . . .	1010.1	- 0.2	81	44	66.6	51.1	58.9	- 3.1	52.6	7.0	62	2.18	- 0.35	19	7.3	49	
Wellington, N.Z. . . . .	1011.6	- 1.7	82	46	69.8	55.7	62.7	+ 0.2	59.0	7.3	66	2.07	+ 1.26	13	8.1	55	
Suva, Fiji . . . . .	1007.2	- 0.3	96	73	88.1	75.0	81.5	+ 1.6	75.4	5.7	75	4.84	- 6.59	19	7.6	58	
Apia, Samoa . . . . .	1006.7	- 1.2	89	71	85.1	74.9	80.0	+ 1.0	76.7	8.2	67	23.01	+ 5.96	20	5.2	41	
Kingston, Jamaica . . . . .	1014.2	- 0.9	90	65	85.9	67.7	76.8	- 0.0	65.2	3.8	81	0.67	- 0.29	2	8.2	73	
Grenada, W.I. . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	
Toronto . . . . .	1014.8	- 3.1	55	5	40.0	27.2	33.6	+ 11.4	29.0	..	78	1.41	1.38	8	3.0	32	
Winnipeg . . . . .	1012.2	- 8.7	33	..	11.9	- 7.3	2.3	+ 6.2	..	5.7	..	0.00	0.91	0	2.3	27	
St. John, N.B. . . . .	1013.7	- 1.8	47	0	35.2	18.3	26.7	+ 7.5	23.7	6.3	..	2.41	2.39	12	3.1	34	
Victoria, B.C. . . . .	1009.9	- 6.1	49	29	42.3	35.9	39.1	+ 0.1	33.5	7.3	56	4.95	+ 0.41	21	2.1	24	

\* For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen.

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## The Colour of Moonlight

The Editor of the *Meteorological Magazine* has asked me to sum up the interesting correspondence which has resulted from my letter in the November number raising the question why moonlight appears blue.\*

Space does not permit me to reproduce all the opinions expressed and to discuss each in turn, so I propose to give my own final impression after carefully studying the whole correspondence and making further observations on my own account. The whole problem may be divided into two separate questions:—

(a) What is the physical colour of a landscape illuminated by moonlight?

(b) Why is moonlight associated with a blue colour in the minds of most people and in the pictures of most artists?

To the first question there is only one reply: physically the colour of a landscape illuminated by moonlight is the same as it would be if illuminated by sunlight. The only change is one of intensity, sunlight being approximately 400,000 times as bright as moonlight. This applies both to the colour of the sky and to the colour of the ground and objects on it.

The reply to the second question follows directly from this when we take into account the physiological factor of the threshold of colour vision. Whether the sky is overcast or clear the brightness of the sky is always greater than the brightness

\*See *Meteorological Magazine*, Vol. 67, 1932, pp. 234, 254, 256, 284; Vol. 68, 1933, pp. 9, 135.

of the ground and objects on it. The brightness of objects illuminated by the moon (except those very near to the observer) is always below the colour threshold. Therefore no colour can be seen on the surface objects, they can only be distinguished by different intensities of illumination to which no colour term can be applied. On the other hand the brightness of the sky in moonlight often approaches and occasionally exceeds the colour threshold. But the colours of the sky are very limited. Neglecting for the moment the reds associated with sunrise and sunset the colour of the sky is always blue with varying amounts of white. In full daylight the colour of the sky can only change from a deep blue, through a milky blue to white or grey. If therefore any colour at all can be distinguished in moonlight it can only be the blue of the sky. That the intrinsic brightness of the blue sky in moonlight can exceed the colour threshold is quite certain and is testified to in the correspondence by Mr. Bennett's figures and Mr. Bonacina's direct observations. Thus if any colour at all can be seen in a moon-lit landscape it must be blue and only blue.

Returning for a moment to the reds of sunrise and sunset: these must be present to the same extent in moonlight, and we all know that the moon itself on rising and setting is often a deep red or golden yellow, and the only reason why we do not see these colours in the sky at moon-rise and moon-set is because the scattered red light is too weak to rise above the colour threshold. In any case the possibility of some red light in the sky just at moon-rise and moon-set does not detract from the above argument that in bright moonlight blue is the only colour which can be discerned by the eye.

Now let us consider the artist who wishes to paint a moonlight scene. His high lights are all in the sky and these must be some shade of blue. Now he wishes to indicate the form of the landscape, but all this has no colour except where it directly reflects the colour of the sky. He must therefore paint his whole picture in gradations of blue, ranging from the bright blue of the sky to the blacks of his deepest shadows. The reverse is equally true: when we see a picture ranging from blue to black we at once associate it with moonlight. Thus we have the explanation of the picture which I saw in Cockspur Street and which started the whole correspondence—a photograph of a ship, obviously taken in daylight, but which appeared to be taken in moonlight, because printed on blue photographic paper.

G. C. SIMPSON.

### **Resultant Wind Direction in London: its periodicities and its effect on rainfall**

By C. E. P. BROOKS, D.Sc., and THERESA M. HUNT.

In May last we contributed to the Royal Meteorological Society

a statistical paper on the variations of wind direction over the British Isles, which will be published in the *Quarterly Journal* for October, 1933. This paper gives the resultant direction of the wind for winter, summer and the year, over as long a period as possible, for London, Edinburgh and Dublin. The resultants are described as "direction-frequency vectors," in other words, they are obtained by giving equal weight to each observation of wind direction, without taking into account the velocity. The data obtained include a long complete series of resultants for London from 1787 to 1930, and this series seemed to offer an excellent basis for an investigation of the periodicity of wind direction in London.

In the paper presented to the Society the data are given in the form of resultant direction in degrees and "constancy," the latter being expressed as a percentage. For the investigation of periodicity, however, it was more convenient to utilise the north and east components which were already available in the working sheets. These figures were first explored by means of the "difference periodogram,"\* which affords a rapid survey of any long series of observations, the finer details being examined more closely after the approximate lengths of the major periodicities had been found by the rougher method. The preliminary analysis suggested the existence of periodicities of approximately 3,  $4\frac{1}{2}$ , 5,  $6\frac{1}{2}$  and 11 years, but of these only the 3-year cycle appeared with any definiteness in both the north and east components, with a length between 2.95 and 3.05 years. The 5-year cycle appeared clearly in the north, but not in the east component. Periodicities longer than 15 years were looked for by the usual direct methods. The investigation was confined almost entirely to the figures for the year, but the possible existence of a 2.5-year component of the 5-year cycle was verified by reference to the data for winter and summer.

Subsequent examination was carried out by the ordinary method of harmonic analysis. The annual and semi-annual cycles were also calculated for comparison. The results are shown in the following table as the constants  $a$  and  $\phi$  (amplitude and phase) of the series  $W = a \sin(t + \phi)$ .

Period. Years.	N. Component.		E. Component.	
	Amp. %	Phase at Jan. 1, 1931.	Amp. %	Phase at Jan. 1, 1931.
0.5	5.0	248°	6.0	226°
1.0	0.1	308	4.4	339
3.0	4.3	27	0.6	117
4.5	2.3	240	3.0	125
5.1	6.1	22	0.8	90
6.5	2.4	250	1.7	78
11.2	1.8	61	1.3	69
24	3.3	217	1.8	7
51	2.8	202	4.5	300

The standard deviations of the annual wind resultants are

\*London, *Proc. R. Soc.*, 106A, 1924, p.346.



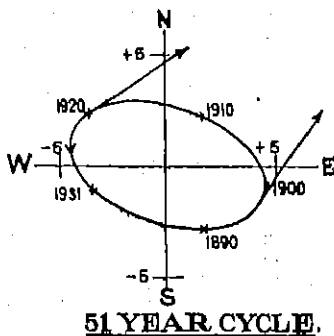
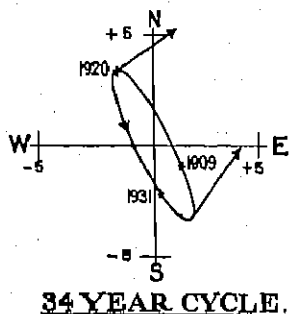
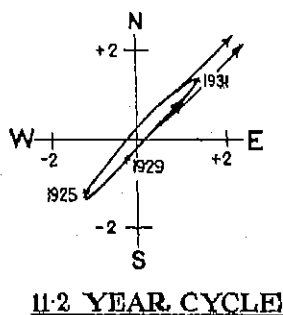
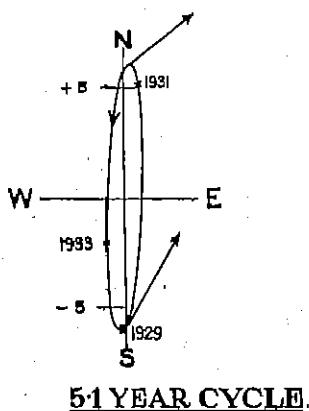
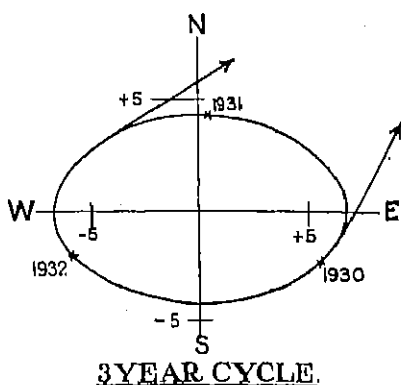
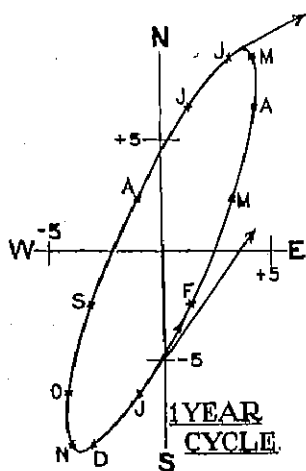


Fig. 1.—WIND PERIODICITIES.

5.7 per cent. for both the north and east components.\* The average resultants of the whole period are: N component 15.2 per cent; E component 14.9 per cent, in other words the average wind direction in London is almost exactly from SW.

The annual periodicity, and those of 3.0, 5.1, 11.2, 34 and 51 years, are shown graphically in figure 1, which may require some explanation. The intersection of the areas represents the average wind direction on which the periodicities are superposed. Each figure is divided by these axes into four quadrants; a point in the upper right-hand quadrant represents the superposition of a wind from NE. on to the average wind, in the upper left-hand quadrant a wind from NW., and so on. Thus in the figure for the 3-year cycle, if we suppose the cycle to begin in 1930, at the middle of that year, represented by the small cross, a wind from SSE. is superposed on the normal SW. wind. As the year passes, the superposed wind becomes first easterly and then north of east. By the middle of 1931 the superposed wind is northerly, early in 1932 it becomes westerly, and at the end of 1932 it is southerly. Since, however, this 3-year cycle is superposed on a fairly steady SW. wind, the average variation of the actual wind resultant during the cycle is only from SSW. to WSW., as is shown by the two short arrows tangent to the ellipse. Even this amount of variation, however, is quite considerable. Similar arrows are shown on the remaining ellipses.

The diagrams present several points of interest. The first is that, contrary to the usual run of meteorological phenomena, the annual periodicity is little more marked than the longer cycles. The second point is the varying nature of the ellipses, that for the 3-year cycle approaching a circle while the 5.1- and 11.2-year cycles are almost linear. The third point is that the direction in which the resultant follows the ellipse is counter-clockwise in all six cases. We will return to this point later.

The 1-year cycle forms a long, narrow ellipse, the winds being most westerly and least constant in early summer, least westerly and most constant in winter. The constancy is shown by the length of arrows from the point where they touch the curve to the point at which they would meet if produced. It should be remarked, however, that as the half-yearly term is almost as large as the annual term, the actual annual variation is much more complicated than that shown, which is included merely for comparison. The 3-year cycle has the largest variation of the east-west component of any of the periodicities affecting the winds of London—larger even than the annual variation—but the north-south oscillation is less marked. It will be

---

\*Owing to the difficulty introduced by the great change of average direction about 1810, the standard deviation was calculated indirectly from the change between one year and the next.

remembered that a 3-year cycle was for a time very prominent in the rainfall of the British Isles.

The 5.1-year cycle was discovered by Mr. E. Baxendell\* in the frequency of northerly and north-easterly winds at Southport and Greenwich, and also in many other meteorological records of the British Isles. It is also significant that there is a periodicity of five years in the occurrence of winters of severe frost in London. From the results obtained here, which otherwise closely confirm those of Mr. Baxendell, it would appear that the variation appears mainly in the frequency of northerly and southerly winds.

The 11.2-year cycle is inserted for its general interest, although it is really insignificant (the scale of this ellipse is double that of the others). It appears definitely as a variation in the constancy of the SW. wind, without appreciable change of the average direction. It should be noted that the last sunspot maximum occurred in 1928, so that there is a lag of three years between the sunspot maximum and the least steadiness of south-west winds.

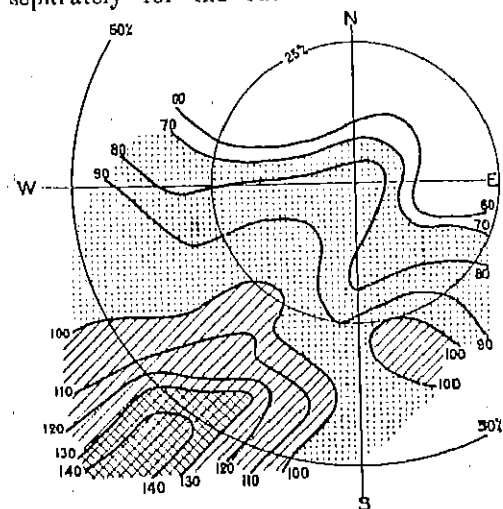
The 34-year periodicity presumably represents the Brückner cycle, but the exact length was rather indeterminate. More definite is the 51-year cycle, which is also clearly shown in the rainfall of England. The last rainfall maximum occurred in 1926, when the wind was most westerly; the dry periods correspond with the greatest easterly component, as would be expected.

We have already referred to the curious feature that the direction of oscillation of the resultants is in all these cases anti-clockwise, as shown by the arrows on the ellipses. We cannot see any obvious explanation of this, but we may perhaps venture a suggestion. The annual cycle can be regarded as a result of the annual variation of the sun's radiation in the neighbourhood of the British Isles, working through the distribution of land and water. If the longer cycles are also of solar origin (this is known to be true of the 11.2-year cycle and strongly suspected for the Brückner cycle) it would be reasonable to expect that they should take the same general course. Against this is the point that the major axes of the ellipses are all inclined at different angles to the horizontal, and at present we do not think it would be profitable to pursue the matter further.

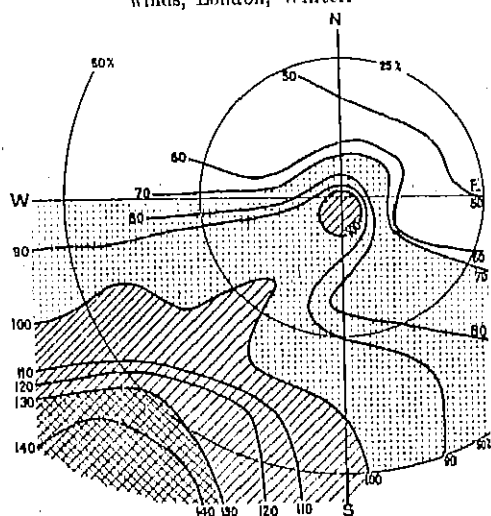
The wind resultants were also used to examine the relation between the general direction of the wind during a season, and the rainfall during the same season. The results are shown in figures 2 and 3. Here resultant wind direction and "constancy" are shown by reference to two axes at right angles, while the two circles represent constancy of 25 and 50 per cent. Thus a point on the left-hand axis labelled "W" represents a

\**London, Q.J.R. Meteor. Soc.*, 51, 1925, p.871.

resultant wind from west. The results were worked out separately for the rainfall of London (1797-1930) and for



Rainfall (percentage of normal) and resultant winds, London, Winter.



Rainfall (percentage of normal) England and Wales and resultant winds, London, Winter.

Fig. 2.

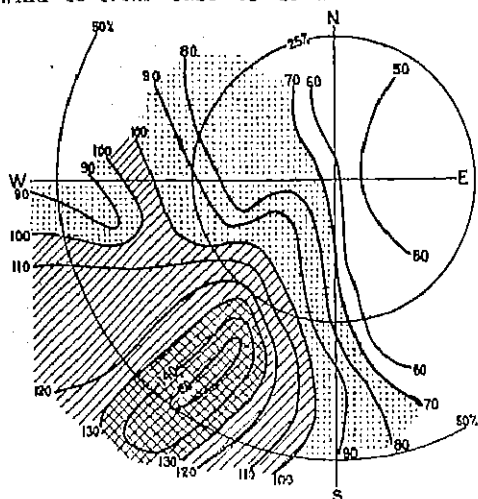
"England and Wales" (1727-45, 1747, 1787-1930)\*, but in each case the winds refer to London. Rainfall is given as a percentage of the normal for the period 1831 to 1915. The winds for the period 1787 to 1840 have been corrected to make them comparable with the observations at the Royal Observatory; the data for 1727-45 were obtained at Richmond and those for 1747 at St. John's Gate, and have not been corrected.

Figure 2 shows the results for winter (December, January, February). The upper half shows the diagram for London. The figures for individual seasons required a good deal of smoothing and the minor details may not represent real phenomena, but the general result is clear, and is in accord with experience. The heaviest rains come when the

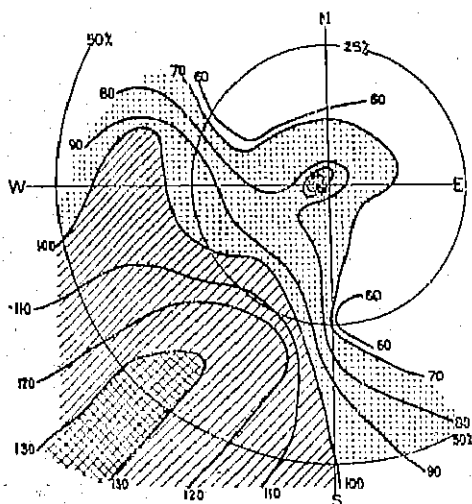
winds blow steadily from south-west (actually a little south of

\*: *British Rainfall*, 1931, pp. 209-306.

south-west). The seasonal rainfall is least when the prevailing wind is from east to south-east or from a little west of north; with north-easterly winds the deficiency is somewhat less pronounced. There is a small area of rain above normal with winds a little south of east which, from the plotting of the individual values, appears to be a real phenomenon. The heavily shaded area represents an expectation of rainfall above 130 per cent. of normal, the lightly shaded from 130 to 100, the stippled area from 100 to 70, and the white area below 70 per cent.



Rainfall (percentage of normal) and resultant winds, London, Summer.



Rainfall (percentage of normal) England and Wales, and resultant winds, London, Summer.

Fig. 3.

rainfall above normal at the intersection of the axes, i.e., in

the lower half of the diagram shows the corresponding results when the winds of London are compared with the average rainfall of England and Wales. This is on the whole very similar to the London diagram, including even the relative raininess of winds from north-east compared with winds from east and from west of north.

An additional feature of interest however is the area of

seasons with no predominant wind. These presumably represent seasons in which series of depressions passed directly across England, giving highly variable winds.

Figure 3 gives similar results for summer (June, July, August). London rainfall is again shown above. This differs from the diagram for winter in several interesting respects. While a wind from south of south-west is still the greatest rain-bringer, the heaviest seasonal totals (exceeding 150 per cent.) occur when the constancy is less than 50 per cent. With steadier south-westerly winds the rainfall again decreases. It may be that thunderstorms, which bring a considerable part of London's summer rainfall, become less frequent when the south-west winds are unusually persistent. A similar decrease is shown for westerly winds of unusual steadiness. The secondary maximum of rainfall with north-easterly winds has disappeared, and the driest conditions are given as would be expected by winds from due east. The diagram for England and Wales as a whole differs in several respects. The range of values is considerably less, and the closed maximum with south-west winds of moderate constancy has disappeared—perhaps because the part played by thunderstorm rains relative to orographic rains is less important for the country as a whole than for London alone. The smallest totals occur with winds from a little west of north and east of south, and the secondary maximum with very variable winds appears as in the winter.

The narrowness of the area of heaviest rainfall is a remarkable feature in three of the four diagrams. The most favourable direction of the resultant for heavy rain is: London, winter,  $218^{\circ}$ ; London, summer,  $213^{\circ}$ ; England and Wales, summer,  $220^{\circ}$ . This holds over a range of constancy of 20 per cent. or more, yet a change in the resultant wind direction by only 10 degrees may change the expectancy of rainfall by 10 per cent. or more. It is an interesting problem why a season in which the prevailing wind blows from a little south of south-west should normally have so much more rain than a season in which the prevailing wind blows from a little west of south-west or a little west of south.

The diagrams may be described as a novel form of rainfall wind rose. They may be compared with a similar diagram for an equatorial island—Ocean Island—which was published in the *Meteorological Magazine* for March, 1926, p. 42. The results for England are not so sensational as for Ocean Island, but they do serve to illustrate our climate from a somewhat unusual angle.

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Mr. A. Westley of Cripps House, Blisworth, Northamptonshire, has 27 copies of *British Rainfall* from 1894 to 1920 in excellent condition which he would like to sell at a reasonable price.

## Correspondence

To the Editor, *The Meteorological Magazine*.

### Cyclone in the Fiji, Tonga, and Cook Island Groups

On the early morning of January 5th, 1933, the Union Steamship Company's R.M.S. *Maunganui*, Captain A. T. Tuten, encountered the central portion of a tropical cyclone. During the period from December 30th to January 5th, pressure was unusually low and the weather very disturbed over a wide area in the tropics extending from west of Fiji to east of the Cook Islands. On January 1st a depression, which appeared from the information available to be only a shallow one, was situated west of Rarotonga (Cook Islands). This depression evidently passed south of Rarotonga on the 2nd. In the meantime a deep cyclone had appeared about 200 miles north of Suva on the 1st. This cyclone moved fairly steadily in an east-south-east direction to the position where the *Maunganui* passed through it. Both storms appear to have developed along the same cold front and moved in a direction almost parallel to it.

The following is taken from an account furnished by Mr. J. E. Brompton, 3rd Officer of the *Maunganui*. The vessel was on a voyage from San Francisco to Wellington via Papeete (Tahiti) and Rarotonga:—

*Jan. 1st.* Left Papeete at 17h. Weather fine and clear, wind light northerly, bar. 1009mb.

*Jan. 2nd.* Northerly wind freshened and sky became cloudy. At noon it was overcast and gloomy and a moderate north-west swell was setting in. Bar. 1007.6mb. At 13h. 30m. a drizzle commenced and continued to 15h. At 18h. the wind freshened and towards midnight there were heavy squalls (up to force 9-10) and rain. Bar. at 24h. 1004.2mb.

*Jan. 3rd.* At 8h., wind N. 6, reaching force 9 in squalls, weather *ov.*, bar. 1000.5mb., visibility poor to moderate. Rarotonga sighted at 9h. The north-westerly swell increased as the Island was approached, being recorded as WNW. 6 on the international scale. The vessel was unable to take up her usual anchorage. At noon, wind had backed to WNW. 4-5, bar. 1002.6mb., weather *org.* These conditions continued till midnight, when bar. read 1001.9mb.

*Jan. 4th.* At 1h., wind fell light (NW. 2) and rain ceased. At 1h. 30m. wind came from SW., force 5-6, and backed rapidly to SE. by 2h. and moderated. At 4h., bar. 1003.8mb. north-west swell moderated rapidly and vessel stood in, anchoring at 5h. 43m. At 8h., bar. 1006.2mb., weather overcast but fine, wind SE. 3. The weather deteriorated during the afternoon, rain setting in. Rarotonga was left at 17h. 20m., the course being 221°. At 18h., wind ENE. and backing during heavy rain. At 19h. 40m., wind NNE. 4. At 20h., wind N. 4-5,

bar. 1003.3mb., weather overcast with heavy rain, which ceased at 20h. 15m. Thunder and vivid lightning observed from 20h. to 21h. Heavy rain again from 21h. 30m. to 22h. 15m., when sky had an ugly, threatening appearance. At 23h., wind NNE. 7-8, sea rising rapidly. At 23h. 55m., wind NNW., force 12, with a mountainous sea and vessel heve to.

*Jan. 5th.* At 0h. 30m., bar. 969mb., wind showing signs of moderating. At 0h. 50m., bar. 972 mb., wind WSW. 7, sky overhead through the spume was seen to be clear with stars shining. The wind continued to back and barometer to rise as follows:—

1h. 15m. WSW. 11-12, bar. 976mb.

1h. 30m. SW. 12, „ 980 „

2h. 00m. SSW. 12, „ 985 „

This was the height of the storm, the wind of terrific force with a mountainous confused sea. The vessel's boats were lifted out of their keel chocks (4 inches) and several stove in. The weather accident boat, carried outboard in strops, was lifted and only saved by the davits from capsizing on deck. A notice re propellers outside the poop railings was torn from its bolts and disappeared. Several ventilators were lifted from their coamings, and two plugs (wooden) to ventilator shafts not in use were blown out. A heavy sea was shipped on the port quarter and the side rails were torn away. At 2h. 20m., bar. 992mb., wind SSW. 10. At 2h. 45m. a noticeable improvement had taken place, bar. 993mb., wind force 7-8, sea heavy and confused with an occasional very heavy swell. At 3h. 20m., wind SSW. 7, bar. 995.3mb., temperature 75.3°, heavy but fast moderating sea, sky clear. At 3h. 30m. the weather had so far improved that an easy full speed was possible, and the vessel resumed her course. At 4h., wind SSE. 7, bar. 996mb., sea south-south-east 5, swell, south 7, sky clear, except for low bank of black cloud to southward. At 8h., wind SE. 5, bar. 1004.2mb., sea south by east 4, confused moderate swell, weather overcast but fine.

From this account and the rate of travel of the storm, it would appear that the severe central portion could not have been more than 30 to 70 miles in diameter. The times given are ship's times, but the dates are New Zealand dates.

E. KINSON.

*Meteorological Office, Wellington, New Zealand. May 4th, 1938.*

[This account shows several features of interest: the winds from NNW., force 12, on the eastern side of the depression and from SSW., force 12, on the western side, separated by a period of lighter winds from WSW., during which the sky cleared overhead. Evidently the ship passed slightly to the north of the storm centre. Although barometer readings during the approach of the cyclone are not given, the fall of the barometer was evidently almost as rapid as the subsequent rise.—Ed. M.M.]



### Peculiar Temperature Phenomenon

On passing along the 4 mile flat road through the open Burgh Marsh at 9.30 p.m. B.S.T. on the evening of July 18th, the writer passed through alternate hot and cold bands of air, each about 50 yards wide, the change from one band to the next being very sudden.

Although a thick ground mist was to be seen on either side of the road within 100 yards, there was no mist along the road itself, while the only ditches in the vicinity run alongside the road, and not across the line of it.

This would tend to dispel the suggestion that the sensation of cold was caused by suddenly entering a zone of air in which the humidity was increased by the presence of a ditch, and I should be interested to hear the opinions of readers as to the cause.

R. H. JENKINS.

*Town Hall, Skegness, Lincolnshire. July 19th, 1933.*

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### Spells of Sunshine

The letters of Mr. Dunbar and Mr. Bilham in the April and May numbers of the *Meteorological Magazine* have prompted me to examine the Lympne sunshine records for the 12 years, 1921 to 1932, with a view to determining the frequency of sunny or dull spells which satisfy certain specified conditions. May I suggest that instead of making the period of a sunny spell 30 consecutive days or more, as has been proposed, we adopt 29 days as the limit? This is the length of period laid down in the definitions of rain spells and partial droughts, and it would, I feel, be an advantage to use the same period in classifying spells of sunshine. The period of 15 days suggested for bright spells and dull spells is already equal to that used in determining droughts and wet spells.

Assuming then that a sunny spell is "a period of at least 29 consecutive days on all of which there is recordable sunshine," Lympne had 24 sunny spells in the 12 years 1921-32. These sunny spells were practically all confined to the summer months, but one commenced as early in the year as February 21st (1924) and two others began on March 6th (1921) and March 7th (1928). The spells frequently extended to the latter half of September, but only one continued into October. This unusually late sunny spell lasted for 36 days from September 20th to October 25th, 1921. The duration of the spells varied considerably. Five just satisfied the conditions, lasting exactly 29 days; five lasted for more than 50 days and two for more than 100 days. These two remarkable spells extended from May 8th to August 20th, 1921, and from May 24th to September 27th, 1928. Over these periods of 105 and 127 days

respectively the recorded sunshine reached the high average of eight and a half hours daily. The mean duration of all the 24 spells was 45 days.

Mr. Bilham suggests that a bright spell might be a period of 15 days each with "one-fourth of the possible mean daily duration." If this criterion is applied to the Lymgne records it is found that 16 such spells occurred in the past 12 years, varying in length from 15 to 26 days. It seemed worth while to determine how many cases occur if criteria other than "one-fourth" are adopted, and Table I shows the results of taking one-tenth, one-fifth, one-quarter, one-third and one-half of the possible mean daily duration as the criteria.

TABLE I.—*Periods of 15 days or more, each day having a proportion of the possible mean daily duration of sunshine equal to or exceeding that shown in the first line of the table.*

	1/10	1/5	1/4	1/3	1/2
Number in 12 years ... ..	31	10	16	10	1
Length of longest spell (days) ...	54	27	26	23	16
Mean length of spells (days) ...	23	24	19	17	16

Of the 16 sunny spells which satisfy the proposed condition, the most in any one year was three in 1921. None occurred in 1922 and 1926. The table appears to indicate that Mr. Bilham's suggestion that "one-fourth of the possible mean daily duration" should be the criterion of a sunny spell is admirably chosen.

Examination of the records suggests that "a period of at least 15 days, none of which has one-fourth of the possible mean daily duration" is too limiting as a definition of a dull spell. Only one period fell within these limits in the 12 years' observations at Lymgne. Table II shows the results of using proportions of the possible mean daily duration similar to those utilized in the determination of bright spells.

The results indicate that, if a period of 15 days or more is to be adhered to, it will be necessary to make the limiting condition "one-half of the possible mean daily duration." This introduces an anomaly which at first may appear serious since it would be possible, in theory, for a sunny spell to be also a dull spell. In practice this has not happened in 12 years and the chance of it occurring, even in 100 years, is sufficiently remote to be ignored.

The proposed definition of a sunless spell as a period of 15,

or even 10, successive days with no recordable sunshine seems to be putting the limit unduly high. A well-exposed station, free from the effects of town smoke and not subject to frequent

TABLE II.—*Periods of 15 days or more, no day having a proportion of the possible mean daily duration of sunshine exceeding that shown in the first line of the table.*

	1/10	1/5	1/4	1/3	1/2
Number in 12 years ... ..	0	1	1	2	13
Length of longest spell (days) ...	—	16	16	17	20
Mean length of spells (days) ...	—	16	16	17	19

fogs would rarely record such a spell. Not a single instance occurred at Lympne between 1921 and 1932. Mr. Bilham notes one such spell at Kew in 1931, but I think he would admit that Kew is affected by London's smoke and by the river fogs. The longest sunless spell at Lympne was 8 days from November 27th to December 4th, 1927; one sunless period lasted for 7 days and three others for 6 days each. A week without sunshine has an unpleasant effect upon most of us, and I suggest that it is sufficiently noteworthy to be classified even though this would be a departure from the original plan in fixing the length of a spell.

Lympne is 350 feet above mean sea level, two miles from the coast and remote from factories and other sources of smoke production. It is, therefore, favourably situated for recording abundant sunshine; but this could be urged in regard to a majority of health resorts. One might then anticipate that, except in the vicinity of towns or in areas subject to excessive cloudiness, sunny and bright spells will outnumber dull and sunless spells. Having these facts in mind the investigation leads to the suggestion that the following definitions are likely to serve best as a means of classifying sunshine records:—

Sunny spell.—At least 29 consecutive days each with recordable sunshine.

Bright spell.—At least 15 consecutive days each with 25 per cent or more of the possible mean daily duration.

Dull spell.—At least 15 consecutive days none of which had more than 50 per cent of the possible mean daily duration.

Sunless spell.—At least 7 consecutive days with no recordable sunshine.

H. E. CARTER.

*Lympne Air Port, Hythe, Kent, June 16th, 1933.*

### Mirage

The fine days of July 2nd, 3rd, and 4th, 1933, produced some extraordinary mirage effects as viewed over the Irish Sea from Holyhead at sunset.

Usually in exceptional visibility the Isle of Man, situated over 50 miles from Holyhead, appears to the observer as two detached mounds. During the three days in question the whole coastline, stretching through some  $20^\circ$ , was apparent, the undulations, probably much distorted, being very clear. Through binoculars one gained the impression of an island with a very indented coastline especially on its northern side. The phenomenon was observed closely on the 4th from 21h. 30m. B.S.T. and at 22h. 15m. inverted images began to form on the tops of the undulations, the whole island being in a state of continuous change. At times the inverted images were detached thus giving the idea of isolated rocks in the sea on the northern side of the Island.

At 22h. 15m. when the phenomenon was most marked the screen temperature was  $59^\circ$ ; the relative humidity was 88 per cent., a trace of mixed cloud was present and the surface wind was light northerly. The observer was approximately 40 feet above Mean Sea Level.

H. L. PAGE.

*Salt Island, Holyhead. July 6th, 1933.*

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### Luminous Clouds

There was an occasion of luminous cloud observed at Holyhead at 4h. G.M.T. on June 19th, 1933, which seems to be worthy of note. There were 3/10ths of strato-cumulus present, and in a north-westerly direction a trace of cirrus cloud in the shape of a tuft above a layer of strato-cumulus. The cirrus was a bright white and was at an elevation of some  $5^\circ$  above the horizon. The night was "light," with good visibility and there was an occasional flash of lightning to the east.

On the previous day the weather had been squally with slight rain in the forenoon, followed by heavy rain showers in the afternoon, with the wind reaching gale force in squalls from a westerly point.

H. L. PAGE.

*Salt Island, Holyhead. July 6th, 1933.*

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At 0h. 45m. B.S.T. on July 3rd, a small, luminous and somewhat lenticular patch of what was classed by the observer to be cirro-cumulus, was observed at an elevation of  $5^\circ$  approximately to the north-north-west. The only other type of cloud present was a layer of strato-cumulus, lying so low on the

northern horizon, as to make the latter invisible. The total amount of cloud present covered rather less than one-twentieth of the sky, which was fairly starry, it being near moonset. The cirro-cumulus had a phosphorescent-like luminosity and was shadowed in parts.

The sky in its immediate vicinity had a whitish-blue appearance, which was the more arresting since it was placed between the faint haze afterglow of the sunset above the strato-cumulus to the north and the remainder of the appreciably darker sky. The cloud patch was observed for about half an hour in all—the amount and elevation appearing very gradually to be increasing and its luminosity was becoming more marked.

At approximately the same time on the 5th, luminous clouds of the same nature were observed in very similar circumstances as in the above, except that the cloud amount was appreciably less, and had a lower elevation. The weather for the past few days had been fine and quiet with exceptional visibility at times.

W. I. JONES.

*Salt Island, Holyhead. July 6th, 1933.*

## NOTES AND QUERIES

### Hailstorm in Derbyshire

According to a letter from Mr. L. Ramsbottom, the Royal Agricultural Show at Derby enjoyed fine but hot weather throughout its five days, except for one brief interval on Friday, July 7th, when a thunderstorm of unusual severity broke over the ground at 2 p.m. The skies darkened, and a few minutes later large hailstones and pieces of ice fell for ten minutes. Very quickly the ground was white all over, and many hailstones were seen as large as gooseberries. Eggs displayed in baskets were broken by the hail. A quarter of an hour after the storm had ceased visitors were picking up the pieces of ice, still the size of marbles, from the ground, and finding in them, cool refreshment under the hot conditions prevailing.

[From descriptions in the *Derbyshire Times*, also sent by Mr. Ramsbottom, the same storm was experienced in the Belper district, eight miles from Derby, shortly after 2 p.m. Many windows and greenhouses were shattered by hail and four cows were killed by lightning. Three of the cows were standing three or four yards from a large ash tree, which was struck. The tree is surrounded by barbed wire, and the bark was stripped to the level of the wire, below which it was intact. Between 30 and 40 wooden stakes supporting the wire round the field were all split, and bark was stripped from trees and bushes touching the wire. The hailstones were the size of marbles. During the storm a hole appeared in the road in Belper Lane; for several feet round the road was forced up into little mounds or waves. The cause is not clear.

At Chesterfield, 24 miles from Derby, the storm, which began

just before 3 p.m., was accompanied by a small whirlwind 20 or 30 feet high, which uprooted small trees and carried newly-mown-hay hundreds of yards; it also carried large quantities of grit and sand. Tiles and slates were dislodged from roofs and part of a building in course of erection was blown down, but there were no personal injuries.—[Ed., *M.M.*]

### High Pilot-Balloon Ascents at Shoeburyness

Mr. C. E. Britton's note in the *Meteorological Magazine* for July on two exceptionally high pilot-balloon ascents which were made at Shoeburyness on June 15th, seems to point to the existence of a remarkable ascending current on the morning of that day. The balloons used weighed 750 grammes. Little is known about the rate of ascent of balloons of this size in still air, nevertheless, certain conclusions, which seem to be of interest, can be reached. The formula used in this country for the rate of ascent  $V$  of balloons is as follows:—

$$V = q \frac{L^{\frac{1}{2}}}{(W + L)^{\frac{1}{2}}}$$

where  $L$  is the free lift and  $W$  the weight of the balloon in grammes. This formula is based on the assumption that the air resistance varies directly as the cross-sectional area of the balloon and as the square of its velocity through the air. It is known that the formula does not hold rigorously for balloons of widely different sizes, and this is allowed for by assigning a different value to the constant  $q$  for large pilot balloons from that used for the smaller sizes. The value of  $q$  is best determined by measurement of the rate of ascent of the different balloons. There is abundant evidence that a value of 276 gives the rising velocity (in feet per minute) of the normal pilot balloons weighing 20-30 grammes satisfactorily, while the value 310 is suitable for the large pilot balloons used for certain purposes which weigh 80 grammes. It is a long extrapolation from these weights to the 750 grammes balloons used at Shoeburyness, but the value of  $q$  calculated from the rate of ascent of the balloon sent up in the evening of June 15th, works out at 358, a figure which seems to the writer not unreasonable for a balloon of this size. If this value be accepted, the similar balloon liberated in the morning, which had a larger free lift, should have risen 910 feet per minute, whereas actually the rate of ascent for the first 10 minutes, as determined by two theodolites, was 1,260 feet per minute, an excess of 350 feet per minute or almost 6 feet per second. A rising current of this magnitude extending for a height of nearly  $2\frac{1}{2}$  miles must be almost unique among upper air observations.

It is understood that further ascents of the same nature are

planned at Shoeburyness, and it will be of interest if such are successfully accomplished to have further information regarding the value of  $q$  which is appropriate to these balloons.

J. S. DINES.

### The Supposed Periodicity in the Size of Waves

There is a well-known superstition that every seventh wave is larger than the others. I happened to be on the beach on the south coast at high tide on a roughish day, April 12th last, and it occurred to me to test this. After each wave I accordingly wrote down an estimate of its intensity, based on the height of the crest, the noise of impact on the shingle, and the distance which it ran up the shelving beach. Altogether 152 waves were estimated in this way, on a scale ranging from 1—the smallest wave which could be distinguished—to 10, the largest wave seen before the count was begun. The estimates actually written down ranged from 1 to 8.

A subsequent examination of the figures showed a certain rhythm, but the periodicity was definitely not seven. The correlation coefficients between each wave, and the first, second . . . tenth subsequent waves were as follows:—

1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
+26	—11	—02	+07	+06	—05	—10	—07	—10	—22

There are thus indications of a periodicity of 4 to 5, but the most marked feature was a variation of longer period. The length of the latter varied, however, the intervals being 17, 20, 16, 21, 15, 13, 15, 19. Probably some of the smallest waves were not independent. On this particular occasion, however, there was certainly no support for the popular belief.

C. E. P. BROOKS.

### Meteorological Service in French Equatorial Africa

An article in the "Dépêche Coloniale" for March 22nd-23rd gives an account of the reorganisation of the meteorological service in French Equatorial Africa, to assist the protection of the air route Franco-Congo-Madagascar. The service is under the direction of an engineer-meteorologist, and its headquarters will be at Bangui, the main aeronautical centre. A number of observing stations are being established, several with pilot-balloon equipment and wireless equipment for reporting daily. In addition to the testing of instruments and the checking and publication of the observations, researches are being undertaken in seismology, terrestrial magnetism and oceanography. First order stations have already been established at Bangui, Fort Lami, Fort Archambault, Impfondo, Brazzaville and Pointe-Noire, and 13 stations of the second order are in operation.

## The Weather of July, 1933

Pressure was above normal over most of Europe (except the extreme north) over the north coast of Africa, the southern North Atlantic including the Azores and Bermudas, Newfoundland, most of eastern Canada, Mexico and California, the greatest excesses being 4.1mb. at Prague and 5.1mb. at 30° N. 10° E. Pressure was below normal over northern Scandinavia, the extreme north of Russia, Spitsbergen, Iceland, Greenland, western Canada and most of the United States, the greatest deficit being 6.6mb. at Spitsbergen. Temperature was generally above normal in western Europe and Spitsbergen, the absolute maximum of 99.3°F. in Uppsala on the 9th was a record for Sweden since at least 1859. Rainfall was below normal in central Europe and Spitsbergen but in Sweden twice the normal in western Norrland and in western Gothaland, 50 per cent above normal in eastern Svealand and slightly below normal elsewhere.

The weather of the British Isles during July was generally warm and sunny, the mean temperature for the month being as much as 5.6°F. above normal at Kew, 4.3°F. at Aberdeen and 2.4°F. at Valentia, while there was an excess of sunshine except on the western coasts and a general deficiency of rain except in Scotland, where the precipitation was excessive locally, and in western Ireland. The month opened with dry sunny warm weather generally. Temperature rose frequently above 80°F., 88°F. was registered at York on the 3rd and the maximum of 86°F. at Eskdalemuir on the 5th was the highest recorded there since records began in 1910. The 2nd to 5th were very sunny days over the country generally, 16.5hrs. of bright sunshine were recorded at Inshkeith and 16.3hrs. at Berwick-on-Tweed on the 3rd. On the 6th a depression was moving northwards on our Atlantic seaboard and thunderstorms occurred over the country generally on the 7th and more locally on the 8th. Minimum temperatures were high at this time, 68°F. being recorded in the screen at Bognor and 66°F. at Southsea, Portsmouth, Worthing, Hastings and Aberystwyth on the 7th. From the 8th until the 15th pressure was low to the north and secondaries frequently passed across the country giving cooler and thundery weather with thunderstorms and heavy rain locally but sunny intervals, 1.68in. fell at Llyn Fawr (Glamorgan) on the 9th and 1.12in. at Edinburgh on the 13th, and at Bath and Frome on the 15th, and maximum temperatures ranged chiefly between 60°F. and 70°F. On the 16th, a wedge of high pressure was approaching from the Atlantic, and sunny anticyclonic conditions prevailed over the whole country for the next few days. Much mist and fog occurred round the southern coasts between the 17th and 19th. From the 19th to 30th pressure was low to the north-west, giving unsettled weather with some rain but many sunny intervals in Scotland and Ireland, while fine warm sunny weather prevailed



in England until the 27th, when there was a change to cloudy, cooler weather. From the 18th to 27th high temperatures occurred in England, reaching a peak on the 27th when 95°F. was recorded at Greenwich and 94°F. at Cambridge and Margate. During the evening of the 27th temperature fell generally as the wind veered to NW. At Edgbaston (Birmingham) a drop of 20°F. was reported between 18h. 40m. and 20h. 10m. Thunderstorms occurred locally on the 19th to 21st, and 27th to 29th. Heavy rain was frequently associated with the thunderstorms, but otherwise rainfall measurements were very slight in England and only moderate in Scotland and Ireland. From the 19th to 27th was a very sunny period in England, among the larger amounts recorded were 15.0hrs. at Aberystwyth and Southport on the 22nd, 14.3hrs. at Skegness and 14.2hrs. at Greenwich on the 26th. On the 30th and 31st a depression passed across the British Isles giving heavy rain in south Scotland, gales locally on the coasts, and cool, cloudy, windy weather with slight rain generally in the west on the 30th and in the east on the 31st. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	127	—18	Liverpool	216	+23
Aberdeen	184	+ 5	Ross-on-Wye	229	+30
Dublin	171	+ 1	Falmouth	223	— 2
Birr Castle	181	+17	Gorleston	250	+10
Valentia	148	—11	Kew	244	+43

The special message from Brazil states that the rainfall in the northern and central regions was generally scarce with averages 0.75in. and 0.04in. below normal respectively, and in the southern regions irregular with an average 0.04in. above normal. Only three anticyclones passed across the country and there was a depression to the south. The crops were generally in good condition except in the central and southern regions where frosts affected the coffee and cocoa. At Rio de Janeiro pressure was 0.8mb. above normal and temperature 1.4°F. below normal.

*Miscellaneous notes on weather abroad culled from various sources.*

Strong south-westerly winds and heavy rain occurred in Iceland on the 5th. A storm occurred over the Venice Lagoon on the 10th, and a brief but violent storm over Isola Bella (Lago Maggiore) just before midnight on the 14th, causing much damage to the famous Borromean Gardens. Heavy rains caused serious floods throughout south Germany during the first half of the month, much damage being done to the hay crops. A temperature of 94°F. was recorded in Berlin on the 28th, the hottest day of the year up to the end of July. Four people

were killed in a heavy storm in the Pirna district in Saxony on the 29th. The 31st was the hottest day at Lisbon for 75 years, the maximum temperature recorded then being 104°F. (*The Times*, July 7th-August 2nd, *Berlin, Taglicher Wetterbericht*, and *British Daily Weather Report*.)

Excessive heat was experienced in the Red Sea early in the month. By the 11th the river level in the gorges of the Yangtze had topped the record at Wanhhsien, but owing to fine weather floods did not follow. On the 6th and 13th it was reported that the monsoon was continuing very active in the Central Provinces and Berars, the United Provinces and in the Punjab, but elsewhere was weak. Heavy rains, however, fell in Bombay and Gujarat on the 15th and 16th, saving the cotton crop in these districts. The rains continued heavy during the rest of the month in western India and communications were interrupted through floods. Many casualties were caused by collapsing houses as well as by the widespread floods. (*The Times*, July 3rd-August 3rd.)

In the northern areas of the Canadian Prairies there was a fair amount of rain during the month, but in the southern areas the weather was dry and hot. Ontario and Quebec were suffering from drought at the end of the month. Temperature was below normal at first in the eastern United States but gradually the warm spell in the western districts extended also to the east. 100°F. was recorded at Albany on the 30th and at New York and Baltimore on the 31st. Twelve deaths from heat occurred in New York. At Fresno, California, 114°F. was recorded on the 27th. Rainfall was on the whole below normal though heavy rain occurred in the Gulf States during the week ending the 18th. The hurricane which did so much damage in Trinidad on June 27th travelled west-north-west doing much damage at Carupano, Venezuela. It then passed about 100-150 miles south of Jamaica striking Grand Cayman Island on July 1st. Owing to the excessive rain which accompanied it roads and bridges in Jamaica were damaged and crops largely destroyed in Grand Cayman Island. The hurricane passed about 300 miles west of Key West on the 4th and then moved across Texas during the night of the 6th-7th. Another hurricane passed Turks Island on the 27th seriously affecting the salt industry by the accompanying heavy rain. (*The Times*, July 3rd-August 3rd, and *Washington, D.C., U.S. Dept. Agric. Weekly Weatherly and Crop Bulletin and Daily Weather Report*.)

### General Rainfall for July, 1933

England and Wales	...	82	} per cent. of the average 1881-1915.
Scotland	...	108	
Ireland	...	90	
British Isles	...	90	

## Rainfall: July, 1933: England and Wales.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>Land</i>	Camden Square .....	0.92	39	<i>Leis.</i>	Thornton Reservoir ...	2.04	100
<i>Kent</i>	Tentorden, Ashenden...	1.47	70	"	Belvoir Castle.....	1.78	72
"	Folkestone, Boro. San.	1.17	...	<i>Kut</i>	Ridlington .....	1.24	40
"	St. Peter's, Hildersham	...	...	<i>Linca.</i>	Boston, Skirbeck .....	1.12	51
"	Eden'bdg., Falconhurst	2.34	102	"	Cranwell Aerodrome...	1.09	73
"	Sevenoaks, Speldhurst	2.30	...	"	Skegness, Marine Gdns	.75	34
<i>Sus.</i>	Compton, Compton Ho.	2.97	105	"	Louth, Westgate .....	1.50	60
"	Patching Farm .....	1.49	62	"	Brigg, Wrawby St. ...	1.48	...
"	Eastbourne, Wil. Sq.	1.48	68	<i>Notts.</i>	Worksop, Hedsok ...	1.18	52
"	Heathfield, Barklyo ...	2.88	116	<i>Derby.</i>	Dorby, L. M. & S. Rly.	1.05	82
<i>Hants.</i>	Ventnor, Roy. Nat. Hos.	1.30	69	"	Buxton, Terr. Slopes	3.17	81
"	Fordingbridge, Oaklands	1.78	89	<i>Ches.</i>	Runcorn, Weston Pt...	1.00	61
"	Ovington Rectory .....	2.49	97	<i>Lanca.</i>	Manchester, Whit Pk.	2.83	86
"	Sherborne St. John ...	1.44	65	"	Stonyhurst College ...	3.47	90
<i>Herts.</i>	Welwyn Garden City...	1.14	...	"	Southport, Hesketh Pk	1.88	60
<i>Bucks.</i>	Slough, Upton .....	1.55	81	"	Lancaster, Greg Obsy.	4.47	128
"	H. Wycombe, Flackwell	2.12	...	<i>Yorks.</i>	Wath-upon-Deane ...	1.41	56
<i>Oxf.</i>	Oxford, Mag. College...	1.08	74	"	Wakefield, Clarence Pk.	2.29	90
<i>Nor.</i>	Pittsford, Sedgebrook...	2.53	107	"	Oughtershaw Hall.....	5.84	...
"	Oundle.....	1.29	...	"	Wetherby, Ribston H.	1.70	68
<i>Heds.</i>	Woburn, Crawley Mill	1.49	67	"	Hull, Pearson Park ...	1.35	58
<i>Cam.</i>	Cambridge, Bot. Gdns.	...	...	"	Holme-on-Spalding ...	1.27	...
<i>Essex.</i>	Cholmsford, County Lab.	.98	44	"	West Witton, Ivy Ho.	2.77	106
"	Lexden Hill House ...	.93	...	"	Felixkirk, Mt. St. John	2.40	90
<i>Suff.</i>	Haughley House.....	1.85	...	"	York, Museum Gdns.	.95	38
"	Campsea Ashc. ....	.94	41	"	Pickering, Hungate ...	1.25	48
"	Lowestoft Sec. School	.93	41	"	Scarborough .....	.85	35
"	Bury St. Ed. Westley H.	2.33	113	"	Middlesbrough .....	1.64	64
<i>Norfol.</i>	Wells, Holkham Hall	1.05	45	"	Balderdale, Hury Res.	...	...
<i>Wills.</i>	Dovizes, Highclere.....	8.02	130	<i>Durh.</i>	Ushaw College .....	1.90	88
"	Osne, Castlaway .....	2.00	83	<i>Nor.</i>	Newcastle, Town Moor	1.01	61
<i>Dor.</i>	Evershot, Melbury Ho.	3.24	128	"	Bellingham, Highgreen	2.23	88
"	Weymouth, Westham ...	1.76	98	"	Lilburn Tower Gdns...	2.87	110
"	Shaftesbury, Abbey Ho.	2.05	103	<i>Cumb.</i>	Carlisle, Sealsby Hall	3.50	107
<i>Devon.</i>	Plymouth, The Hoe ...	2.61	95	"	Borrowdale, Southwaite	10.00	127
"	Holne, Church Pk. Cott.	4.45	120	"	Borrowdale, Mornio...	8.02	...
"	Teignmouth, Den Gdns.	2.19	92	"	Keswick, High Hill...	3.89	101
"	Cullompton.....	3.05	113	<i>West.</i>	Appleby, Castle Bank	2.38	74
"	Sidmouth, Sidmouth...	2.74	109	<i>Mon.</i>	Abergavenny, Larch...	2.45	98
"	Barnstaple, N. Dev. Ath	1.85	60	<i>Glam.</i>	Yatalyfern, Worn Ho.	6.14	134
"	Dartm'r, Cranmore Pool	5.20	...	"	Cardiff, Ely P. Stn.	2.22	71
"	Okehampton, Uplands	...	...	"	Troherbert, Tynywaun	7.90	...
<i>Corn.</i>	Redruth, Trevirgia ...	2.81	92	<i>Carm.</i>	Cardiff, Ely P. Stn.	7.90	...
"	Penzance, Morrah Gdn.	2.47	91	<i>Pemb.</i>	Cardiff, Ely P. Stn.	7.90	...
"	St. Austell, Trevanna...	3.28	98	<i>Card.</i>	Cardiff, Ely P. Stn.	7.90	...
<i>Soms.</i>	Cheyton Mendip .....	2.88	82	<i>Rad.</i>	Cardiff, Ely P. Stn.	7.90	...
"	Long Ashton .....	1.96	69	<i>Mont.</i>	Cardiff, Ely P. Stn.	7.90	...
"	Street, Millfield.....	2.90	118	<i>Flint.</i>	Cardiff, Ely P. Stn.	7.90	...
<i>Glos.</i>	Blockley .....	1.26	...	<i>Mcr.</i>	Cardiff, Ely P. Stn.	7.90	...
"	Cirencester, Gwynfa ...	2.39	98	<i>Carm.</i>	Cardiff, Ely P. Stn.	7.90	...
<i>Here.</i>	Ross, Birchlea .....	1.80	80	"	Cardiff, Ely P. Stn.	7.90	...
<i>Salop.</i>	Church Stretton.....	2.04	82	<i>Ang.</i>	Cardiff, Ely P. Stn.	7.90	...
"	Shifnal, Hatton Grange	3.04	135	"	Cardiff, Ely P. Stn.	7.90	...
<i>Staffs.</i>	Market Drayton, Old Sp.	2.47	92	<i>Ile of Man</i>	Cardiff, Ely P. Stn.	7.90	...
<i>Worc.</i>	Ombersley, Holt Lock	1.84	63	"	Cardiff, Ely P. Stn.	7.90	...
<i>War.</i>	Alcester, Ragley Hall...	1.74	73	<i>Guernsey</i>	Cardiff, Ely P. Stn.	7.90	...
"	Birmingham, Edgbaston	2.11	91	"	Cardiff, Ely P. Stn.	7.90	...
					St. Peter P't. Grango Rd	1.87	93

## Rainfall: July, 1933: Scotland and Ireland.

Co.	STATION	In.	Per- cent of Av.	Co.	STATION	In.	Per- cent of Av.
Wig.	Pt. William, Monreith	3.02	107	Suth.	Melvich	4.80	157
	New Luce School	8.12	92		Loch More, Achfary	5.09	96
Kirk.	Dalry, Glendarroch	5.60	160	Caith.	Wick	2.21	84
	Cairns, Shiel	7.17	187	Ork.	Doorness	1.25	49
Dumf.	Dunfries, Orickton, R.I.	3.37	109	Shet.	Lerwick	1.99	87
	Eskdalemuir Obs.	6.85	107	Cork.	Caheragh Rectory	4.12	...
Roxb.	Branksholm	3.50	118		Dunmanway Rectory	3.84	98
Selk.	Ettrick Manor	6.55	147		Cork, University Coll.	2.00	74
Perth.	West Linton	4.49	...		Ballinacarra	2.30	82
Berw.	Marchmont House	3.85	120	Kerry.	Valentin Obsy.	3.94	104
E. Loth.	North Berwick Res.	2.47	96		Gearahameen	6.40	111
Midl.	Edinburgh, Roy. Obs.	4.78	109		Killarny Asylum	...	...
Lea.	Auchtylshale	...	...		Dacrynano Abbey	4.17	114
Ayr.	Kilmarnock, Kay Pk.	4.06	...	Wat.	Waterford, Gortmore	2.18	69
	Girvan, Pinnore	4.44	122	Tip.	Nonagh, Cas. Lough	2.62	80
Renf.	Glasgow, Queen's Pk.	3.05	135		Roscrea, Timoney Park	2.45	...
	Greenock, Prospect H.	3.77	96		Cashel, Ballinamona	2.60	90
Bute.	Rothsay, Ardencraig	4.98	...	Lim.	Poynes, Coolnanes	2.89	94
	Dougarie Lodge	3.94	...		Castleconnel Rec.	2.97	...
Arg.	Ardgour House	8.30	...	Clare.	Inagh, Mount Callan	5.78	...
	Glen Elvie	...	...		Brondford, Hurdlest'n.	3.37	...
	Oban	0.08	158	Wexf.	Gorey, Courtown Ho.	2.30	78
	Poltalloch	5.83	142	Kilk.	Kilkenny Castle	1.86	66
	Inveraray Castle	5.05	119	Wick.	Rathnew, Clonmannon	2.28	...
	Islay, Ballabus	3.34	98	Carl.	Hacketstown Rectory	2.97	86
	Mull, Benmore	13.50	...	Leis.	Blandsfort House	2.64	84
	Three	4.40	123		Mountmellick	2.91	...
Kinr.	Loch Leven Shulce	...	...	Offaly.	Birr Castle	3.12	106
Perth.	Loch Dlu	...	...	Kildr.	Monasteravin	...	...
	Balquhider, Stronvar	3.44	...	Dublin	Dublin, Fitz Wm. Sq.	1.87	65
	Orkell, Strathearn Hyd.	3.28	110		Balbriggan, Ardghillan	1.79	66
	Blair Castle Gardens	2.70	105	Meath.	Bonapare, St. Cloud	2.53	...
Angus.	Kettins School	2.63	101		Kells, Headfort	2.26	71
	Pearse House	3.13	...	W. M.	Monte, Coolatore	2.71	...
	Montrose, Sunnyside	3.10	120		Mullingar, Belvedere	2.76	87
Aber.	Braemar, Bank	2.09	105	Long.	Castle Forbes Gdns.	3.90	128
	Logie Coldstone Sch.	2.65	90	Gal.	Ballynahinch Castle	5.84	120
	Aberdeen, King's Coll.	3.08	110		Galway, Grammar Sch.	...	...
	Fyvie Castle	3.44	108	Mayo.	Mallaranny	4.86	...
Moray.	Gordon Castle	3.11	97		Westport House	3.14	101
	Grantown-on-Spey	...	...		Dolph Lodge	7.77	117
Nairn.	Nairn	2.02	70	Sligo.	Markree Obsy.	2.97	86
Inver.	Ben Alder Lodge	2.37	...	Cavan.	Belturbet, Cloverhill	2.12	68
	Kingussie, The Birehes	2.50	...	Ferm.	Enniskillen, Portora	...	...
	Loch Quoich, Loan	6.75	...	Arm.	Armagh Obsy.	2.76	95
	Glenquoich	2.14	33	Down.	Fofanny Reservoir	4.13	...
	Inverness, Oulduthol R.	3.23	...		Seaford	3.86	105
	Arisaig, Fairo-na-Sguir	4.88	...		Donaghadee, C. Str.	2.15	77
	Fort William, Glasdrum	...	...		Banbridge, Milltown	2.44	75
	Skye, Dunvegan	2.46	...	Antr.	Belfast, Cavehill Rd.	3.38	...
	Barra, Skallary	3.85	...		Aldergrove Aerodrome	2.54	91
R & O.	Alness, Ardross Castle	2.73	90		Ballymena, Haryville	2.53	74
	Ullapool	2.59	82	Lon.	Londonderry, Creggan	3.70	101
	Achnashellach	5.28	108	Tyr.	Omagh, Edonfel	2.82	77
	Stornoway	2.40	82	Don.	Malin Head	4.33	...
Suth.	Lairg	1.52	49		Milford, The Manor	3.25	98
	Tongue	2.70	88		Killybegs, Rockmount	4.92	112

## Climatological Table for the British Empire, February, 1933

STATIONS	PRESSURE			TEMPERATURE						PRECIPITATION			BRIGHT SUNSHINE	
	Mean of Day M.S.L.	diff. from Normal	mb.	Absolute		Mean Values			Mean Cloud Amt	Relative Humidity %	Mean Amt	Days	Diff. from Normal	Hours per day
				Max.	Min.	Max.	Min.	1/2 min.						
	° F.	° F.		° F.	° F.	° F.	° F.	° F.	° F.	%	in.	in.	in.	Per cent. possible
London, Kew Obey.	1015.8	+0.4	56	25	36.0	45.9	37.2	40.9	7.3	85	0.10	13	1.11	28
Gibraltar	1017.3	-2.7	71	37	48.4	55.5	48.3	55.5	4.6	82	2.65	10	0.14	27
Malta	1012.8	-3.3	63	42	58.9	54.7	50.5	54.7	6.5	75	4.97	14	0.57	49
St. Helena	1011.4	-0.5	72	59	69.7	62.0	65.9	62.0	9.1	94	2.77	17	..	..
Freetown, Sierra Leone	1012.5	+1.7	90	69	86.5	74.4	80.5	74.4	9.1	90	1.93	3	..	..
Lagos, Nigeria	1009.9	+0.2	91	72	88.7	77.3	83.0	77.3	3.8	85	0.57	5	0.27	61
Kaduna, Nigeria	1010.4	-3.0	100	56	93.7	77.8	77.8	77.8	5.2	85	2.05	5	0.15	75
Zomba, Nyasaland	1007.2	-0.7	85	62	80.3	64.9	72.6	64.9	3.8	75	0.00	0	0.02	8
Salisbury, Rhodesia	1009.9	-0.6	87	51	78.9	57.4	68.1	57.4	7.7	67	4.97	15	5.68	..
Cape Town	1013.0	-0.4	105	53	80.3	60.4	70.3	60.4	5.7	67	5.36	12	1.46	58
Johannesburg	1009.0	-0.3	91	45	81.9	56.9	69.4	56.9	3.4	73	0.27	3	0.31	..
Mauritius	1009.8	-1.2	89	63	85.3	72.5	78.9	72.5	6.8	60	1.34	11	3.88	68
Calcutta, Allpore Obey.	1012.4	-0.9	83	52	83.3	68.6	75.9	68.6	3.4	74	6.41	18	1.99	58
Bombay	1011.2	-1.5	87	65	83.3	68.6	75.9	68.6	1.2	89	2.59	3*	1.60	..
Madras	1012.0	-0.9	90	64	85.4	68.9	76.9	68.9	0.0	84	0.00	0*	0.03	..
Colombo, Ceylon	1010.3	-0.5	89	68	86.2	72.0	79.1	72.0	3.4	75	0.00	0*	0.30	..
Singapore	1009.5	-0.7	92	80	88.5	71.0	79.7	71.0	4.1	76	1.92	8	0.66	70
Hongkong	1016.3	-2.3	79	53	65.1	56.9	61.0	56.9	4.9	77	1.92	5	4.70	62
Sandakan	1009.7	..	90	72	85.6	74.7	80.1	74.7	8.6	85	0.10	17	1.73	31
Sydney, N.S.W.	1010.3	-3.6	93	53	77.9	63.1	70.5	63.1	8.1	68	16.21	5	5.24	..
Melbourne	1011.9	-2.6	99	48	77.2	54.5	65.9	54.5	5.9	66	0.23	17	3.97	..
Adelaide	1013.2	-1.0	108	51	80.1	60.3	73.2	60.3	5.1	60	0.23	6	1.48	62
Perth, W. Australia	1017.0	+4.0	112	58	90.3	66.8	78.5	66.8	2.6	39	0.18	2	0.54	80
Coolgardie	1010.9	-1.6	113	56	97.3	65.0	81.1	65.0	2.4	45	0.11	4	0.34	77
Brisbane	1011.3	-1.2	98	60	86.1	67.4	76.7	67.4	3.1	35	0.02	1	0.83	..
Hobart, Tasmania	1007.6	-5.6	77	43	66.6	49.9	58.3	49.9	6.2	59	1.50	9	3.90	69
Wellington, N.Z.	1007.5	-8.3	78	50	67.3	56.9	62.1	56.9	6.2	76	1.50	11	0.02	58
Suva, Fiji	1007.0	-0.3	92	75	88.3	76.3	82.3	76.3	7.6	81	3.75	10	0.61	42
Apia, Samoa	1008.1	-0.3	89	72	85.9	74.9	80.4	74.9	6.4	79	12.51	25	1.79	48
Kingsdon, Jamaica	1015.7	+0.4	59	65	86.2	67.4	76.8	67.4	7.1	81	22.71	0	7.42	48
Grenada, W.I.	..	..	..	..	..	..	..	..	2.7	81	0.00	0	0.60	83
Toronto	1015.2	-2.3	46	..	32.3	19.9	26.1	19.9	..	..	0.99	5	1.39	..
Winnipeg	1015.9	-5.9	39	..	9.0	12.8	1.9	12.8	..	..	0.00	0	0.74	43
St. John, N.B.	1010.2	-3.7	49	2	34.4	19.2	26.8	19.2	..	..	0.00	11	0.75	31
Victoria, B.C.	1020.8	+4.2	48	17	41.6	32.7	37.1	32.7	7.2	81	2.80	13	0.46	37

\* For Indian stations a rain day = a day on which 0.1 in. or more rain has fallen.

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## Temperature Readings on London Roofs

During the recent spells of hot weather most of the London newspapers published hourly readings of temperature taken on the roof of the Air Ministry, Adastral House. The instrument in use is a mercury-in-steel thermograph, the bulb of which is installed in a Stevenson screen on the roof, while the recorder is in a room on the fifth floor. The same screen contains ordinary maximum and minimum thermometers read daily at 9h. It was found at the end of July that the thermograph was reading about a degree higher than the thermometers in the screen, and the necessary adjustments to the thermograph were subsequently made. The readings quoted in this article are those from the maximum thermometer, not the thermograph.

The readings at the Air Ministry are taken mainly for the purpose of answering the numerous inquiries which are always received during exceptional weather conditions. They are not regarded as being comparable with readings taken under the standard conditions set out in the "Observer's Handbook" and are not included in any Meteorological Office publications. It is, however, a matter of some interest to ascertain how the roof readings compare with those taken at nearby stations on the ground. In London there are now four stations at which thermometer readings are regularly taken in Stevenson screens on

100ft Particulars of these are as follows —

*Adastral House Kingsway* Asphalt roof about 90 feet above street level

*South Kensington (Meteorological Office)* Asphalt roof about 60 feet above street level

*Oxford Street (Selfridge & Co Ltd)* Screen on grass in roof garden about 90 feet above street level

38 *Holborn Viaduct F C 1* (Messrs Negretti and Zambra) Lead covered roof about 80 feet above street level

For comparison purposes we have four meteorological stations in which the screens are exposed on grass in the standard manner These are St James Park Kensington Palace Camden Square and Regent's Park Further afield there are such stations as Hampstead Tottenham and Kew Observatory in the suburbs but we are concerned in this inquiry with conditions in inner London The maximum temperature recorded on each day of July at all the eight stations is given in the attached table

Looking first at the mean values for the month we see that there is surprisingly little difference between the roof stations as a whole and the ground stations as a whole The mean for the four roof stations ( $76.1^{\circ}\text{F}$ ) is  $0.3^{\circ}\text{F}$  lower than the mean for the four ground stations ( $76.4^{\circ}\text{F}$ ) When this investigation was started it was thought that the heated asphalt roof at Adastral House had the effect of raising the readings there above the values appropriate to a normal exposure but the actual data show that this is not the case; the readings agreeing well with those at Kensington Palace and Regent's Park The lowest mean value is that for Negretti and Zambra's roof station in Holborn and the next lowest that for St. James Park The "hottest" station is Camden Square where the surrounding houses probably interfere seriously with the flow of air It is of interest to add that at Richmond (Kew Observatory) the mean maximum for the month was  $75.9^{\circ}\text{F}$  in the north wall screen attached to the Observatory building and  $75.8^{\circ}\text{F}$  in the Stevenson screen normally exposed on the lawn These figures differ little from the values for Adastral House St. James Park Kensington Palace, Regent's Park Oxford Street and Holborn which seems to dispose of the idea that the use of a north wall screen results in the publication of abnormally low readings of maximum temperature at Kew Observatory during spells of hot weather

Further investigation is necessary to explain why the roof at South Kensington is relatively warm and that at Holborn relatively cool The point of most interest is that the readings taken on the Air Ministry roof do in general give a very fair representation of the average conditions in London during a warm period — a good representation as would be given by a

normal station on the ground. No doubt a very different result would be obtained if a similar comparison were made using

# READINGS OF MAXIMUM TEMPERATURE IN JULY 1933

Date	Roof Stations				Ground Stations			
	Adastral House	South Kensington	Oxford Street	Holborn	St. James Park	Kensington Palace	Camden Square	Regent's Park
1	76	78	78	77	75	78	79	70
2	74	75	74	72	78	75	77	77
3	84	85	80	83	84	80	87	87
4	85	85	81	84	88	86	87	85
5	69	70	70	68	68	70	71	71
6	78	77	78	70	77	79	81	79
7	88	81	82	83	82	88	84	84
8	78	75	78	74	70	74	76	75
9	72	78	72	72	72	78	74	74
10	69	71	69	72	69	70	70	70
11	66	67	66	66	66	66	65	66
12	78	72	72	71	71	72	74	73
13	65	65	64	65	65	64	66	65
14	78	74	78	72	72	78	74	73
15	68	69	67	66	66	67	69	69
16	1	71	71	70	72	71	73	71
17	71	70	70	71	70	69	71	70
18	77	78	78	70	77	77	78	79
19	80	82	79	80	70	80	82	81
20	82	88	81	82	80	80	82	81
21	78	70	70	77	80	79	79	78
22	78	70	78	78	78	78	79	79
23	82	88	88	81	88	82	85	82
24	84	85	84	88	88	84	85	85
25	88	88	81	81	80	81	85	88
26	87	89	87	86	86	87	89	88
27	90	91	90	90	90	91	98	98
28	75	75	74	74	75	74	78	75
29	72	72	71	71	72	72	74	72
30	75	75	74	78	74	75	77	75
31	66	69	66	66	66	65	65	66
Mean	76.1	78.8	75.9	76.5	75.6	76.2	77.6	76.8

Mean of four roof stations = 76.1 F. Mean of four ground stations = 76.4 F.  
 minimum temperatures during a cold period in the winter. The deduction to be drawn is not that a roof is a suitable site for a Stevenson screen but that the Stevenson screen is so effective



a radiation-shield that a good approximation to the air temperature can be obtained even on an asphalt roof in hot weather.

### Further Records from the northern Pennines

The following abstract gives a further summary of the records of temperature obtained at Moor House, Upper Teesdale, since last September.\* The mean difference of temperature between Moor House and Durham is very much what might be expected for the difference in height. Maxima for the period under review average  $6.6^{\circ}\text{F}$ . below those at Durham, minima  $3.8^{\circ}$ ; but the departures from the Durham figures vary considerably in different months. In January, a cloudy month on the moors, the departures were  $5.3^{\circ}$  and  $2.0^{\circ}$  only. March as a whole was clear and dry, with large lowland ranges of temperature; the maxima at Moor House averaged  $6.2^{\circ}$  and the minima  $2.4^{\circ}$  below those at Durham. It may be mentioned that the greatest daily range occurred on the 26th ( $59^{\circ}$ - $31^{\circ}$ ), and it will be noted that the Moor House minima in this month averaged only  $0.7^{\circ}$  below those of Appleby, which lies about eight miles to the south-west. The latter station is quite low down in the Eden valley, which is well known locally for the greater severity of its spring night frosts compared with the hillsides a mile or two distant. As a whole, therefore, comparisons are better made with either Durham or Newton Rigg, in assessing the differences between the high moors and the lowlands. I have, however, added the Appleby figures to those given for Durham below, as the station is the nearest to Moor House which provides records of temperature.

It is clear that in calm weather the air temperature on the moorland closely approaches that of the lowlands; e.g., August 11th, 1932,  $77^{\circ}$  against  $78^{\circ}$  at Durham and Newton Rigg; and June 4th, 6th, 7th of 1933 each gave  $76^{\circ}$  at Moor House against  $79^{\circ}$ ,  $78^{\circ}$  and  $78^{\circ}$  at Durham. Also a maximum of  $57^{\circ}$  on March 12th (Durham  $57^{\circ}$ ) may be cited. On the other hand, given a more breezy type of weather the differences are great; during the past very warm July the mean maximum at Moor House was  $62.8^{\circ}$ , Durham  $71.3^{\circ}$ ; yet on the 4th, Moor House recorded its highest maximum so far ( $79^{\circ}$ )—equal to that recorded in Durham on the same day; in this instance the Durham figure was kept down by the onset of a welcome afternoon sea-breeze. On the previous day a westerly breeze gave  $75^{\circ}$  at Moor House, but  $85^{\circ}$  in Durham. It seems clear from this and other instances that the Crossfell plateau lies away from the

\* See *Meteorological Magazine*, Vol. 67, 1932, p. 206.

immediate influence of the North Sea; this is, for example, suggested by the figures quoted below for May.

Minimum temperatures have not at any time this year fallen exceptionally low, and May gave a minimum temperature for

### TEMPERATURES 1932-3.

	<i>Mean Mean Mean Extremes</i>					<i>Mean Mean Mean Extremes</i>				
	<i>Max.</i>	<i>Min.</i>				<i>Max.</i>	<i>Min.</i>			
Sept. Moor House	47.5	53.9	41.2	72	29	Durham	53.0	60.8	45.7	75 80
						Appleby	52.0	59.9	44.1	75 28
Oct. Moor House	40.1	44.8	35.6	54	20	Durham	45.7	52.1	39.3	58 80
						Appleby	44.7	51.5	37.8	59 25
Nov. Moor House	36.8	40.1	33.0	50	20	Durham	42.5	47.2	37.8	58 26
						Appleby	41.7	46.7	36.7	59 24
Dec. Moor House	30.0	30.0	34.1	48	26	Durham	41.5	45.0	37.7	59 28
						Appleby	41.1	45.8	36.3	54 25
Jan. Moor House	31.4	34.9	27.9	47	16	Durham	35.1	40.2	29.9	54 15
						Appleby	34.7	40.1	29.2	53 18
Feb. Moor House	32.0	35.3	28.7	46	10	Durham	38.0	42.0	33.1	55 25
						Appleby	36.9	42.3	31.6	52 19
Mar. Moor House	30.2	45.6	32.8	59	20	Durham	43.5	51.3	35.2	65 28
						Appleby	43.0	52.5	38.5	64 26
Apr. Moor House	40.6	46.2	35.0	57	23	Durham	46.9	53.9	39.8	66 28
						Appleby	46.5	53.0	39.2	63 26
May Moor House	46.1	52.5	39.7	66	33	Durham	50.2	56.3	43.6	69 34
						Appleby	52.2	60.2	44.2	73 35
June Moor House	52.5	61.1	43.9	76	32	Durham	57.1	66.8	48.0	79 40
						Appleby	57.7	68.0	47.4	82 33
July Moor House	56.2	62.8	49.6	79	42	Durham	62.2	71.3	53.2	85 47
						Appleby	61.2	70.4	52.0	83 43

Height of Moor House 1,840 ft., of Durham 336 ft. and of Appleby 440 ft.

the month of 33°. There was practically no snow after the beginning of March; and the big fall at the end of February was not regarded as exceptional at Moor House, although there were very large drifts. The quantity of snow seems to have been heavier further east. It appears that exceptionally low temperatures on the plateau demand a rather rare combination of circumstances; it remains to be seen what the coming winter will bring before coming to conclusions regarding this and many other points.

GORDON MANLEY.

## OFFICIAL NOTICE

### Discussions at the Meteorological Office

The series of meetings for the discussion of recent contributions to meteorological literature, especially in foreign and colonial journals, will be resumed at the Meteorological Office, South Kensington, during the session 1933-4. The meetings will be held on alternate Mondays at 5 p.m., beginning on Monday,

October 16th, 1933, when Lt.-Col. E. Gold, D.S.O., F.R.S., will open the discussion of a paper by S. K. Banerji and H. M. Wadia, entitled *Evaporation and its measurement* (1st paper). (Calcutta, India Meteor. Memoirs 25, Pt. 9, 1932, pp. 291-325.)

The dates for subsequent meetings are as follows:—

October 30th, November 13th and 27th, December 11th, 1933; January 15th and 29th, February 12th and 26th, and March 12th, 1934.

The Director of the Meteorological Office wishes it to be known that visitors are welcomed at these meetings.

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## Correspondence

To the Editor, *The Meteorological Magazine*.

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### Rain near Centre of Anticyclone

A curious example of rain near the centre of an anticyclone occurred here yesterday, August 4th, between 8 p.m. and 9.30 p.m. B.S.T.

Large drops of rain fell at intervals, amounting on two occasions to a smart shower, the total fall being 1.8 mm. The corrected barometer reading was 30.34 in., and Buxton was near the centre of a large high-pressure system which at the time was moving slowly north-east. The day had been oppressively close and humid (max. temp. 76°F.), and even at this altitude (1,000 feet) the air was stagnant, there being no appreciable wind from any point. There was much haze and some cumulus clouds of no great size or height. About 8 p.m. the sky became overcast, but it was so misty that the character of the cloud could not be determined. It should be emphasised that the rain was definitely of the large drop, thundery type, but no thunder or lightning occurred. The rain was definitely not of the "slight rain" or drizzle type occasionally experienced in anticyclones.

I am unable to account for this fall, having regard to its position in the anticyclone, and the apparent almost complete absence of air movement.

E. C. RUTHERFORD.

10, Grosvenor Mansions, Buxton. August 5th, 1933.

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### Heavy Rain at Mangatuna, N.Z.

Perhaps the following may be of interest. It is from my son, H. E. Cave, from Mangatuna, about seven miles from Gisborn, on the east coast of the North Island, New Zealand. "It had been raining quietly and steadily for about 24 hours, and at 9 a.m. on the 26th May we had 2.51 in. for the two previous days. At 6.45 that evening I found . . . the rain-gauge overflowing, holding 4.05 in. An hour and a-half later I went

out again and measured 2.45 in. At 9 a.m. the next morning the rain-gauge was again overflowing with another 4.05 in., making 10.55 in. for the 24 hours, but of course there was actually more, though I have no idea how much. During the next 24 hours we got a further 5.57 in."

There was thus 16.12 in. for two days, and 18.83 in. for the four days. The very heavy rain was rather local, as Gisborne had only about 7½ inches for the two days.

C. J. P. CAVE.

*Stoner Hill, Petersfield. August 23rd, 1933.*

## Cloud

It would be interesting to know the month and year when least cloud has been recorded, on the scale 0-10, at any station in the British Isles. My own observations during 22 years (except for a period during the War) give a minimum of 2.9 at Colchester in July, 1911. Other months with small amounts of cloud in south-east England are April, 1914 (3.7), and September, 1914, (3.6).

Since 1919, in the Midlands, I have never noted less than 4, and this only in spring or autumn months. August, 1933, with 4.8, is unusual.

G. C. WOOLDRIDGE.

*Market Harborough. September 2nd, 1933.*

[The "Radcliffe Observations" for 1920-30 contain, in the Appendix, a table giving the mean cloud percentage for each month from 1881 to 1930. In this period of 50 years the lowest entry is 35 per cent for September, 1928. The percentage was 39 in July, 1911, 38 in April, 1914, and 44 in September, 1914. It should be mentioned that the Oxford observations refer to the mean of 9h., 12h. and 21h. Mr. Wooldridge does not say to what hour, or combination of hours, his observations refer. In the *Monthly Weather Report*, Table IV, the data in regard to cloudiness are printed separately for each hour of observation, and the importance of specifying the observing hours may be illustrated by the fact that for the year 1932 the mean cloud amount at Kew Observatory was 7.1 at 7h., 7.9 at 13h., 6.9 at 18h., and 6.1 at 23h. (on the scale 0-10). A complete reply to Mr. Wooldridge's question would clearly involve a good deal of research.—*Ed., M.M.*]

## Unusual Cloud Formation Observed at Weston Zoyland Camp

An unusual cloud formation was observed at Weston Zoyland, Somerset, on Thursday, July 27th, at about 10h. 40m. G.M.T. The sky was about 8/10 clouded with mainly alto-stratus and

cirro-stratus. A patch of cloud (about 1/10) resembling stratus, but showing extraordinary convolutions was noticed a little to the south of the zenith at about 10h. 40m. Further small detached cloudlets were observed forming near this cloud and resembled the column portion of a waterspout. The column was pointed at the lower end and broadened towards the top where there was a small tuft of cloud. The lower end of the column appeared to be at about 2,000 ft., while the top of the cloud reached to 2,500-3,000 ft. The top of the column was carried along more quickly than the bottom, with the result that the column soon assumed a roughly horizontal position, though by then it was considerably distorted. These merged into the cloud increasing the convolution effect already observed. The cloud was moving from south to north, and by about 10h. 50m. had passed beyond the zenith. To the north and in advance of the convoluted cloud, further "waterspout" cloudlets were forming, while to the south of the zenith a patch of cloud (about 2/10) showing a mammato formation, had developed. The further cloud formation to the north soon died out and by 11h. 5m. the phenomenon was over and the clouds described had assumed a fracto-stratus formation against an alto-stratus background.

During the early part of the morning (7h.-10h.) the weather was hot and oppressive with a light variable wind. The sky was nearly clear at first but later clouded over with cirro-stratus and alto-stratus. The temperature rose to 78°F. then fell to 75°F. by 11h. A shallow depression centred near the Scilly Isles at 7h. was moving in a north-north-easterly direction.

The peculiar cloud formation was presumably due to the inflow of cooler air as the depression advanced, causing violent ascending currents of warm air which produced the clouds observed. Unfortunately, or perhaps fortunately, no aircraft were flying in the vicinity of the cloud so no reports of "bumpiness" are available.

D. DEWAR.

*Weston Zoyland Camp, Somerset. August 22nd, 1933.*

### The Colour of Moonlight

With reference to Dr. Simpson's article in the current *Meteorological Magazine*, which I am pleased to see, may I, on an incidental point he refers to, point out that clouds and sky occasionally take on a violet hue at midday in midwinter, as well as towards evening at other seasons.

I have often observed this at midday in December, but never, I think, outside that month.

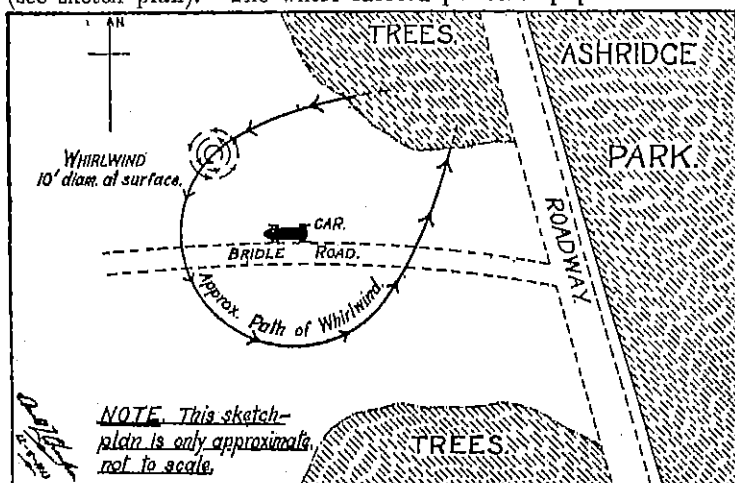
L. C. W. BONACINA.

*35, Parliament Hill, London, N.W.8. August 22nd, 1933.*

### Whirlwind near Great Berkhamstead

I am indebted to Mr. J. Hollingworth, A.M.I.C.E., for the following details of a whirlwind which he observed on May 13th, 1933, the day before a similar phenomenon was seen at Eskdalemuir.

At 5.30 p.m. B.S.T., his car was parked on Berkhamstead Common, at a point about 550 ft. above M.S.L., two miles due north from Great Berkhamstead, Herts. The sky was fairly clear, apart from a few isolated cumuliform clouds, and the air was dead calm. Suddenly a great noise "like the rush of escaping steam" was heard in the adjacent trees of Ashridge Park, and a well-defined whirlwind approached from the east and circled, in a radius of 35 or 40 feet, around the car and passed away almost at the point from which it first appeared (see sketch plan). The whirl carried pieces of paper and other



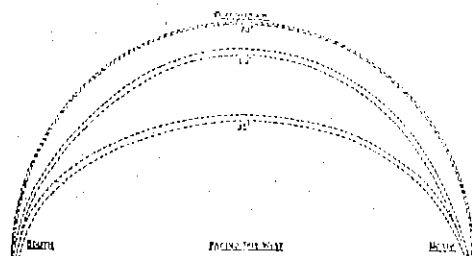
small debris to a height of about 100 feet. Mr. Hollingworth states "a paper bag drawn up rotated in corkscrew motion, and the higher it rose the wider the turning circle appeared. Thus starting at, say, 10 feet in diameter, at a height of 50 feet it might have been 40 or more feet across the turning circle; but the pitch of the corkscrew motion was also varying, thus at the ground it was small, but higher up greater. This would appear to conform with the law of a true vortex."

The rotation of the whirl, and also its motion about the car, was definitely cyclonic, and the time taken in its circuit round the car was about 10 or 12 seconds. After the whirlwind had passed away into Ashridge Park, the air again became dead calm.

DONALD L. CHAMPION.

### Luminous Night Cloud

During the evening of July 24th, 1933, an unusual cloud formation of cirrus was seen at Westcliff-on-Sea, Essex. At 21h. 20m. G.M.T. a belt of cirrus cloud was observed stretching across the western sky at an elevation of  $35^\circ$ , from north to south, forming a bow, and moving in an easterly direction. This was rapidly followed by a second belt, and between 21h. 20m. to 21h. 50m.



eight belts of cloud travelled across the sky from due west to east, the eighth belt disappearing at 21h. 50m. at an elevation of  $105^\circ$ . None of the belts appeared from the west until at an elevation of  $35^\circ$ , prob-

ably because the western sky was too bright at the time to allow of any contrast at lower elevations, nor were any visible after reaching the elevation at  $105^\circ$ . At 21h. 30m. four belts were visible simultaneously at elevations of  $35^\circ$ ,  $55^\circ$ ,  $70^\circ$  and  $105^\circ$  from west. All the belts were approximately  $1\frac{1}{2}^\circ$  in width, the width being even throughout their length.

The belts of cloud were whitish in appearance, the three lower being very clear, whilst that which had passed overhead was considerably less clear. The brilliancy of the belts was similar to that of the Milky Way on a clear moonless night. As the belts of cloud travelled across the sky they presented a striking appearance. As each attained the  $70^\circ$  elevation and beyond, stars in the path of travel were plainly seen through the cloud, which clearly denotes that the cloud belts were very tenuous.

The sky during the time of observation was very translucent, no other clouds were visible; in fact, a perfect summer night, and a calm.

Weather conditions during the preceding two or three days had been very fine.

E. J. HONNEX.

32, Ceylon Road, Westcliff-on-Sea. August 22nd, 1933.

### NOTES AND QUERIES

#### The Effect of Warm Water on Soil Temperature

Mr. G. M. Meyer has raised the question, if a plot of soil were treated with warm water, to what extent would the soil temperature be raised and how long would the effect be noticeable. A theoretical answer to this question presents difficulties, but

Mr. F. J. Seraso kindly made the experiment at Kew Observatory, with the following result:—

On July 20th, at 14h. G.M.T., a generous amount of water at a temperature of 93°F. was poured on a plot of soil containing a bulb of the autographic recorder at a depth of 4 inches. Just previous to adding the water the temperature at 4 inches was 74.0°F. The application of the water caused a rise in temperature on the record of 4.9°F. The warm water was applied at 14h. G.M.T., and by 20h. G.M.T. the effect had disappeared. There was practically continuous sunshine from 11h. G.M.T. until sunset.

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### Campbell-Stokes Sunshine Recorder, "Universal" Pattern

In the "tropical" pattern of Campbell-Stokes sunshine recorder, the sphere is rigidly held in place by means of screws at the two opposed points on the polar axis. By making provision for adjusting the position of the axis and bowl to suit the latitude the same type of support can be used in temperate latitudes. Recorders designed in this way are catalogued by several firms under the description "universal pattern."

It has recently come to the notice of the Meteorological Office that sunshine recorders of this pattern, but fitted with the tropical type of bowl, are sometimes used in this country, and it seems desirable to utter a warning as to the unsuitability of such bowls for use outside the tropics. In temperate latitudes during the summer months the sun will be above the horizon for much more than 12 hours; a duration of burn of 15 hours is not uncommon in the British Isles. In the tropical pattern of bowl the card is only supported for a length corresponding with 12 hours of time, and in consequence the ends of the British summer cards are unsupported for a considerable length if used in this bowl. These unsupported portions of the card will not lie at the correct distance from the centre of the sphere, so that the sun's rays will not be focussed upon them and a good deal of early morning and late evening sunshine will be lost from the record. The standard bowl for temperate latitudes is so cut that support is given to the summer card almost to the extreme end, and it is essential to use this type of bowl in the British Isles if accurate records are to be obtained.

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### Hurricane of June 27th in Trinidad

As mentioned in the *Meteorological Magazine* for July, p. 49, a severe hurricane passed across the south of Trinidad on June 27th. Local newspaper cuttings kindly lent by the West India Committee contain a good description of the changes of wind direction experienced by Mr. H. Fahey at a well-exposed point



near Siparia, close to the south coast, which adds considerably to our knowledge of this unusual storm. The hurricane winds began from north about 7 p.m. and maintained this direction until 8.30, gradually increasing in force. Most of the derricks were destroyed, the broken clocks registering about 8.10. From 8.30 to 9.30 the wind veered from north to due east; high woods and some derricks that had survived the northerly gale fell towards west. After 9.30 the wind shifted from east to south-east by south, blowing from the latter direction at 10.30 p.m. when the hurricane ended. The final stages were accompanied by very heavy rain with a few violent gusts.

These observations clearly show that the storm centre passed to the south of the observer travelling in a direction a little south of west. Observations at Cedros, near the south-western point of Trinidad, show that the centre also passed to the south of that village, where many buildings were demolished including the school. Actually the centre is said to have passed over a tanker at the mouth of the San Juan river, on the coast of Venezuela to the west-south-west of Cedros. Thus it must have been very near the south coast of Trinidad. On the opposite coast of Venezuela the mangroves were damaged for only a few miles inland, and Mr. Fahey estimates the diameter of the storm as only 35 miles.

The storm travelled westward for about 100 miles, and then turned towards the north-west. On the morning of June 29th, the centre was about lat.  $13^{\circ}\text{N.}$ , long.  $70^{\circ}\text{W.}$ , and on the 30th it passed south of Jamaica. Its further course was described in the *Meteorological Magazine* for August, p. 173.

Although this occurrence reminds us that the zone of West Indian hurricanes includes Trinidad, they are very rare so far south, and the only previous records of severe visitations in the island refer to 1884 and 1810. That of February 23rd, 1884, blew down a number of large trees near Port of Spain in the north of Trinidad, but does not seem to have been severe. The hurricane of May 12th, 1810, was more serious; houses were blown down and shipping destroyed, but as in 1884 the damage was confined to the northern part of the island. The hurricane of June 27th, 1933, is thus outstanding for the extreme southerly position of its track as well as for the violence and long life of so small a centre.

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### Hurricane in the eastern U.S.A.

A hurricane of tropical origin traversed the Atlantic coast of the United States on August 23rd and 24th. It was first recorded on August 17th as a disturbance of considerable intensity centred in about lat.  $18^{\circ}\text{N.}$ , long.  $50^{\circ}\text{W.}$ , to the eastward of the Lesser Antilles, moving westward. By the morning of August 18th,

it had advanced to  $54^{\circ}\text{W}$ . and was accompanied by gales. Its track had already begun to curve towards the west-north-west, and on the 19th it was centred about  $22^{\circ}\text{N}$ .,  $61^{\circ}\text{W}$ . On the 20th it lay about 200 miles south-south-east of Bermuda, and the following day it travelled north-westward passing 150 miles west of Bermuda and began to affect the weather on the coast of the United States. On the 22nd it lay about midway between Bermuda and Cape Hatteras, but its movement had become slow and irregular and there was a chance that it would dissipate without doing serious damage. This hope was not fulfilled, for next day the north-westward advance was resumed and the centre crossed the coast at Cape Hatteras. A violent gale with wind velocities of 60 to 80 miles per hour swept the seaboard from Norfolk, Virginia, to New York; several vessels were driven ashore, and high waves destroyed houses, piers and pavilions in the coastal resorts. The winds caused unusually high tides, and several towns, including a large part of Philadelphia, were flooded.

The storm centre passed over Washington on the evening of the 23rd. It was decreasing in intensity, but was still very severe, and according to reports in the Press the barometer fell to 980 mb.; telephone and telegraph wires were broken and many trees uprooted. During the day nearly 7 inches of rain fell in the city, which was extensively flooded, the main electric power station being put out of action. Large areas were flooded in Maryland, Virginia and Pennsylvania, and thousands of people were made homeless. During the passage of the storm along the coast 47 lives were lost and the material damage was estimated at ten million dollars. On the 24th it continued its path northwards towards Canada, but by the 25th its intensity was so greatly diminished that no serious damage was done north of New York.

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### **Duststorm at South Farnborough**

During dry spells and with a fresh southerly or northerly wind small duststorms have been frequently observed in the Long Valley, Aldershot. A similar occurrence during the passage of a front on the afternoon of July 27th, 1933, was, however, on a much greater scale than any hitherto noticed.

The dust was first observed at 14h. 35m. G.M.T. being carried along by a SSW. wind. By 14h. 43m. the wind had increased during the passage of the front to a mean speed of 35 m.p.h. with a maximum gust of 44 m.p.h. The dust had now encroached on to the western side of the aerodrome, obscuring Pyestock woods and reducing visibility to about 800 yards in this direction, and probably to a much less amount in the track of the dust. It appeared to present a solid wall about 100-200 feet

high. There was no general movement of the dust front eastwards across the aerodrome, and as the wind decreased to 25 m.p.h. at 14h. 48m. so the duststorm subsided. A considerable diffusion of dust must have occurred as all objects and papers in the main building of the Royal Aircraft Establishment became covered with a fine layer. A pilot flying at the time reports that the dust extended to a height of 1,000 to 1,200 feet, and conditions were very bumpy up to 3,000 feet. Heavy rain was experienced at 5,000 feet, but little of this found its way down to the surface. Most of what was recorded occurred after the passage of the squall.

The front appears to have moved quickly eastwards in the strong wind prevailing above 1,000 feet. It passed Worthy Down at about 14h. 15m., where a gust of 38 m.p.h. was recorded, and was observed at Guildford a few minutes after passing Farnborough. No change occurred in the wind direction at the surface, which remained SSW. The barograph, however, rose about 2 mb. from 14h. 30m. to 14h. 45m., remained steady for about half-an-hour, and then fell about 3 mb. during the ensuing hour. Temperature fell gradually from 82°F. at 14h. 30m. to 73°F. at 15h. 15m. G.M.T., at which time the sky, which had been covered with nimbo-stratus and alto-stratus above 6,000 feet, had begun to clear in the west. No thunder was reported in this locality although it had been expected.

W. H. BIRD.

(Note on the above)

The cold front moved rapidly across southern England accompanied by widespread slight showers and a little local thunder. The absence of any general or severe outbreak of thunderstorms may be attributed to the low humidity and the correspondingly high level of the clouds. The lapse rate of temperature at Duxford was abnormally high, the mean lapse rate up to 6,700 feet at 12h. 30m. G.M.T. being equal to the dry adiabatic rate. The figures were 93°F. at the ground (100 feet above M.S.L.), 57°F. at 6,700 feet and 42°F. at 10,360 feet. The horizontal temperature gradient was also large, the maximum temperature on July 27th being 99°F. at Paris and 94°F. at Margate, but only 63°F. at Renfrew and 59°F. at three stations in northern Ireland.

At London (Kingsway) the squall arrived at 15h. 5m. G.M.T. and the maximum gust was 35 m.p.h. Temperature on the roof fell from 90°F. to 78°F. in under two hours, but afterwards recovered to 80°F. The barograph behaved almost exactly as at Farnborough, and this suggests that most of the fall of temperature was due to the evaporation of the rain and the cessation of sunshine. A second cold front passed during the night, the wind at Kingsway veering from SW. to NW. at about midnight.

This was really the main cold front, and the fall of temperature was probably large at 1,000 feet, though small at the ground owing to the time being midnight. This front caused no rain at any reporting station in the south-east. The rainfall for the 24 hours was trifling over nearly the whole of England and adjacent regions of the Continent. There was, however, considerable rain and in places also thunderstorms over a large area in Ireland and Scotland, the rainfall mounting to 1.30 in. at Eskdalemuir, 0.75 in. at Inchkeith, and 0.71 in. at Aberdeen. This rain area moved north-eastwards in the same direction as the associated depression, but considerably to the left of the path of the centre, its south-eastern boundary being at least 120 miles from the centre.

The depression moved quickly north-eastward from the bay of Biscay across Cornwall and the Midlands to the Humber, and thence to the Gulf of Bothnia. It deepened slightly during its passage across England, and more markedly afterwards. The pressure at the centre was about 1,011 mb. at 7h. on the 27th, 1,008 mb. at 18h., 998 mb. at 7h. on the 28th, and 985 mb. at 7h. on the 29th.

C. K. M. DOUGLAS.

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### A new Meteorological Station in Massachusetts

We learn from the Bulletin of the American Meteorological Society, April, 1933, that a new meteorological station has been established on Mount Wachusett (2,018 feet), Princeton, central Massachusetts, under the auspices of Blue Hill Observatory of Harvard University, and in connexion with the work of the International Polar Year. There will be no resident observers. A meteorograph, designed and built by Prof. S. P. Fergusson to run for two or three months without attention will keep the record of wind direction and velocity, atmospheric pressure, temperature and humidity.

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### The Degree of Accuracy in Estimating Tenths

The sixth volume of the *Geophysical Magazine* of Japan is dedicated to Professor T. Okada in commemoration of his thirty years' service in the Central Meteorological Observatory of Japan, and contains, in addition to a very fine coloured photograph, an account of his work with a list of his publications and a valuable series of papers on geophysical subjects by his friends and pupils. One of these, by S. Ono,\* presents some interesting statistics on the accuracy with which a scale division can be mentally sub-divided in estimating fractions.

The data were obtained at an exhibition of precise instru-

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\* On the error of observation reading the decimal fraction of a uniform scale. *Geoph. Mag.*, Tokyo, 6, 1932, pp. 387-91.

ments held in Tokyo. Spaces on twelve cards (representing, for example, degree marks on a thermometer) had lines drawn in intermediate positions, and a prize was offered for correctly "reading" the cards to the nearest tenth of a division. The lines were actually drawn in the positions: 0.50, 0.24, 0.33, 0.12, 0.38, 0.72, 0.66, 0.93, 0.40, 0.54, 0.20, 0.80; the correct answers being 0.5, 0.2, etc. There were 4,320 entries, of which 45 were correct and 418 had only one error, while 2,559 had more than half the answers correct. The most accurate estimates were made by government officials and students. It is curious that among the more accurate observers 0.66 was a much greater stumbling block than 0.24.

A number of competitors attempted to give estimates to two places. These were rejected but have also been examined statistically. Certain tendencies were shown. Thus, many competitors appeared to estimate the reading first as a simple fraction rather than directly in tenths. It was also found that values above 0.5 were over-estimated, while values below 0.5 were under-estimated. The investigation throws much light on the psychology of observing and is to be carried further.

## Reviews

*Nautisk-Meteorologisk Aarbog 1932.* The Danish Meteorological Institute, Copenhagen, 1933.

The Danish Meteorological Institute is to be congratulated on the promptitude with which this valuable annual volume is issued. In addition to observations of wind, temperature, salinity and ocean currents in Danish waters, it includes a great deal of valuable information about the North Atlantic and Arctic waters. The summaries of the state of ice in the Arctic are too well known to require description; the series of reports extends back to 1895 and is of very great value in studying variations of the atmospheric circulation and their causes. This year, owing to the presence of several expeditions, the record is unusually complete. Another regular series is continued in the monthly charts of sea surface temperature in the North Atlantic north of 50° and in Davis Strait. All these observations from high latitudes and the corresponding ones for 1933, will be essential when the results of the second International Polar Year come to be discussed. This volume concludes with an index of the contents of the "Nautical-meteorological Yearbook" since 1880, which brings out the great services to oceanography rendered by the Danish Meteorological Institute.

*Über Klimatophysiologie.* By Prof. Dr. A. Loewy. Size 8½ x 6 in., pp. 77, *Illus.* Leipzig, 1931.

The book is a summary of lectures delivered to medical and

meteorological students. It is in two parts, the first part dealing with climatophysiology in general and the second with the physiological effects of special types of climate.

In the general effect of climate on the body the cooling power of the air is more important than the temperature. No formula for the cooling power is given. Two instruments for measuring it are discussed—the kata-thermometer and frigorimeter. A warning is given that the analogy between these instruments and the human body as subjects for the effect of climate should not be pushed too far; they do, however, give an approximation to the heat demand on the body in varying conditions of climate. A table of cooling powers of six different stations shows that Davos, with an annual mean temperature of only  $2.6^{\circ}\text{C}$ . has a mean cooling power of  $9.57$  millical./cm.<sup>2</sup> sec., lower than that of Karlsruhe (mean temperature  $9.7^{\circ}\text{C}$ .), Schreiberhau and Swinemünde.

In the second part the effects of the special types of climate are dealt with rather fully. In the description of "sea climate" it is pointed out that radiation is one of its important characteristics, and ten pages are devoted to recent researches on the effects of the red and violet rays on the body. Under "tropical climate" the importance of acclimatisation is emphasised.

As the lectures are intended for medical students as well as meteorologists, they contain a good deal of physiology and the bodily changes in different climates are dealt with in considerable detail.

*Solar Radiation Measurements at Poona in 1931.* By S. S. Kohli, M.Sc. Calcutta, India Meteor. Dept. Memoirs, Vol. xxv, Part X, 1932.

This paper forms a useful addition to the data of solar radiation in tropical latitudes. For nine months, February to June, 1931, and October, 1931, to January, 1932, observations were made regularly near noon on sufficiently clear days with an Angström pyrheliometer at normal incidence; during the monsoon from July to September there was too much cloud. Observations were also taken throughout the day on suitable days. In addition to total solar radiation, the amounts in the red and infra-red regions in which water vapour is effective were also measured. The results are discussed in detail, and the effect of the varying turbidity and humidity during the year are clearly brought out. The effect of the gradual rise of the layer of haze over Poona to the level of the instrument is shown by a kink in the diurnal curve for November.

The second part of the paper discusses the total energy received from sun and sky on a horizontal surface, measured by a Callendar Pyranometer. These measurements are analysed and compared with the sunshine records, and it is shown that the

radiation received during the monsoon is much greater than that calculated from the duration of sunshine by Angström's formula.

*The latitude shift of the storm track in the 11-year solar period. Storm frequency maps of the United States, 1883-1930.* By C. J. Kullmer. Washington, D.C. Smithsonian Miscellaneous Collection, Vol. 89, No. 2. 1933.

One of the corollaries of Huntington's theory of the shift of climatic belts was that the storm tracks of temperate regions must swing north and south in response to solar changes, and that a similar effect ought to appear during the sunspot cycle. This question was investigated by C. J. Kullmer about 1913 and answered with a slightly doubtful affirmative. Since then the data for two more cycles have become available, and Kullmer has repeated his investigation, with more decisive results. For each area of  $2\frac{1}{2}^{\circ}$  of latitude by  $5^{\circ}$  of longitude the number of storm centres for each year is plotted. The sum for the three years about a spot minimum is then subtracted from the sum for the three years about the following spot maximum and the results again plotted. From these maps it appears that near spot maximum there is an excess of storms in the north of the United States and a deficit further south. The results are not quite regular, the last cycle (max. 1927-9, min. 1922-4) having been especially anomalous, but all follow the same general pattern. The paper will repay detailed study.

### Books Received

*Height of base of clouds in India as determined from pilot balloon ascents.* By the late M. V. Narayanan, B.A., and M. P. Manna. India Meteor. Dept., Sci. Notes, Vol. iii, No. 25. Calcutta, 1931.

*Falmouth Observatory. Meteorological Notes and Tables for the year 1931*, also additional meteorological tables of temperature, rainfall and sunshine, 1880-1931. By W. T. Hooper. Falmouth, 1932.

*Bulletin de l'Observatoire de Talence (Gironde).* 2nd Series, Nos. 19-20; Talence, 1932; and 3rd Series, Nos. 1-4, 1933.

### Obituary

We regret to learn of the death on August 24th, 1933, at the age of 82 years, of Mr. W. G. James, who retired from the Meteorological Office Staff on December 31st, 1910, after 50 years' service in the Marine Division.

### News in Brief

The photograph, accompanying the note on a tornado at Peshawar which appeared on p. 117 of the June number of this magazine, was reproduced by the courtesy of Mr. R. Pleasants.

## The Weather of August, 1933

Pressure was above normal over western and central Europe, (except for most of Scandinavia), over most of the North Atlantic, also over south-western and central Canada and California; the greatest excess was 3·4 mb. at the Scilly Isles. Pressure was below normal over eastern Europe, most of Scandinavia, Spitsbergen, Madeira and also over Greenland, Iceland, northern and eastern Canada and the United States, except the extreme west and the Lake Region. The deficiency was greater than 5 mb. over south Greenland, Iceland and Spitsbergen. Temperature was above normal over western and central Europe and Spitsbergen, while rainfall was generally deficient except at Spitsbergen, being less than half the normal in southern and central Sweden.

August was notable for the small rainfall and abundance of sunshine with high temperatures over the greater part of the British Isles. At several stations in the south of England it was the driest and sunniest August on record. At the beginning of the month an anticyclone was spreading over the British Isles from the Atlantic; weather was fine, sunny and warm generally for several days though there was a little rain in north-west England and Ireland. Day temperatures gradually increased until the 6th which was the hottest day; on that day 91°F. was reached at Cambridge and Margate, 92°F. at Tottenham and South Farnborough and 96°F. at Greenwich.\* The minimum of 67°F. at Kow on the night of the 2nd-3rd and the maximum of 83°F. at Aberdeen on the 3rd were the highest for the first ten days of August at these stations since 1871. On the 6th a shallow trough of low pressure lay over Scotland and Ireland and thunderstorms occurred at a few stations in Scotland. It was cooler generally on the 7th though still warm. There was rain in Scotland and Ireland on the 7th and 8th and in England on the 11th, when thunderstorms occurred in the south with the advance of a shallow depression from France. On the 10th Jersey recorded 16·8 hours of bright sunshine. There were local thunderstorms on the 13th and 14th particularly on the south coast. From the 14th until the 23rd conditions were rather unsettled due to the passage of depressions to the north of the British Isles, and further thunderstorms occurred on the 20th and 21st. Good sunshine records were obtained, however, during this period especially on the 13th, 16th and 19th. Rainfall was slight and irregular, some fell on most days in Scotland, Ireland and western England and on two or three days in the rest of England. From the 24th conditions were anticyclonic over a large part of the country; in the south and east fine sunny weather prevailed until the end of the month and high day temperatures were again reached; on the 28th 88°F. was recorded at several stations, York recorded 89°F. and Hull 90°F. Greenwich recorded

\* In a Glaisher stand.



90°F. on the 29th and 30th. Towards the end of the month, however, Ireland and the north-west of England came under the influence of a depression on the North Atlantic and heavy rain fell on the 27th and 28th; 3.01 in. fell at Aasleagh House and 2.91 in. at Delphi Lodge in Co. Mayo and 2.36 in. at Ballynahinch Castle, Co. Galway, on the 27th, 1.52 in. fell at The Moraine, Borrowdale, and 1.74 in. at Lligwy, Anglesey, on the 28th. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Sternoway	159	+26	Liverpool	189	+26
Aberdeen	188	+38	Ross-on-Wye	244	+70
Dublin	194	+32	Falmouth	228	+17
Birr Castle	181	+30	Gorleston	241	+85
Valentia	160	+4	Kow	250	+63

The special message from Brazil states that rain was scarce in the north, centre and south, the averages being .83 in., .16 in., and 1.22 in. below normal respectively. The passage of four anticyclones caused low temperatures. Frosts occurred in the south during the second decade and strong winds during the first decade. The crops were generally in good condition but in the centre and south they were affected by the frost, especially the tobacco and coffee. At Rio de Janeiro pressure was 1.2 mb. above normal and temperature was 0.7°F. below normal.

*Miscellaneous notes on weather abroad culled from various sources.* A heat wave was experienced generally over southern and central Europe during the first part of the month, 102°F. was recorded at Perpignan on the 7th and at Madrid on the 8th. Violent thunderstorms brought the prolonged heat wave to a close in Austria, Hungary and Switzerland on the 12th, and caused a temporary break in France on the 14th. Lightning and floods caused serious damage in Vienna and the neighbourhood, and in the Interlaken region, where several bridges were carried away; a number of deaths also occurred in Vienna. Forest fires, some caused by lightning, broke out in France on the 13th, 14th and 15th, but were for the most part soon under control, while a hailstorm damaged the crops in the Hérissou district. A break in the heat in northern Italy about the 16th was accompanied by severe storms. Heavy rainfall caused the Kilchenstock to become menacing again. (*The Times*, August 2nd-25th; and *British Daily Weather Report*.)

Severe monsoon weather caused floods in many places early in the month between Rangoon and Mandalay. Heavy rain continued to fall in western India during the first part of the month, and this was followed by serious floods; 15 in. of rain were reported to have fallen in 18 hrs. at Baroda, but the

inundation was not so great as in 1927; two people were killed and about 4,000 rendered homeless. The monsoon was weak outside north-east India during the week ending the 16th, but was active in north-east India, north-west India and the central part of the country towards the end of the month. Flood waters from the Shyok Dam were coming down the Indus on the 28th, but they were subsiding on the 29th, and it was thought that the leak in the Shyok Dam had quickly filled again with ice. Serious floods occurred along the banks of the Yellow River during the later part of the month; thousands of people were drowned in western Shansi and over 300,000 people were rendered homeless in Honan. By the 23rd the floods in western Shantung were subsiding, the rains having ceased for some days. (*The Times*, August 2nd-September 1st.)

Owing to the drought the coffee crop in Kenya is expected to be of poor quality. General rains throughout the Cape and parts of the Orange Free State about the 27th broke one of the worst droughts experienced there. (*The Times*, August 23rd-29th.)

Heavy general rains towards the end of the month broke the drought in South Australia and have been of much benefit to the agricultural and pastoral areas, though the consequent floods did damage to property. (*The Times*, September 1st-2nd.)

Dry, hot weather was experienced generally at first in Canada, followed by fairly general rains near the middle of the month; but there was another period of dry, hot weather before the generous rains at the end of the month which benefited the late crops. A cloudburst occurred south-east of Denver, Colorado, on the 2nd, followed by the bursting of Castlewood Dam, so that Cherry Creek flooded much of the city and surrounding country. A hurricane swept along the Atlantic coasts of the United States on the 23rd and 24th.\* Temperature in the United States on the whole was somewhat below normal at the beginning of the month, but became above normal generally in the western districts later, while the rainfall distribution was irregular. Heavy rain on the 15th in Jamaica culminated in a severe thunderstorm early in the morning of the 16th, when many parts of the Island were flooded; about 40 people were drowned and some 10 bridges destroyed. A hurricane struck the Bahamas on the 31st doing considerable damage, and then moved south-south-west towards Cuba. (*The Times*, August 2nd-31st, and *Washington, D.C., U.S. Dept. Agric. Weekly Weather and Crop Bulletin*.)

### General Rainfall for August, 1933

England and Wales	...	38	} per cent. of the average 1881-1915.
Scotland	...	76	
Ireland	...	58	
British Isles	...	51	

\* See p. 188.

## Rainfall: August, 1933: England and Wales.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>Land</i>	Camden Square .....	·58	26	<i>Leis.</i>	Thornton Reservoir ...	·68	24
<i>Kent</i>	Tentorden, Ashenden...	·86	38	"	Bolvoir Castle.....	·63	24
"	Folkestone, Boro. San.	·87	...	<i>Kut</i>	Ridlington .....	·73	20
"	St. Peter's, Hildersham	...	...	<i>Lincs.</i>	Boston, Skirbeck .....	·40	17
"	Edon'hdg., Falconhurst	1·18	46	"	Granwell Aerodrome...	1·21	46
"	Sevenoaks, Speldhurst	·79	...	"	Skegness, Marine Gdns	·70	81
<i>Sus</i>	Compton, Compton Ho.	1·17	38	"	Louth, Westgate .....	1·03	37
"	Patching Farm .....	1·23	49	"	Brigg, Wrawby St. ...	·35	...
"	Eastbourne, Wil. Sq.	1·17	47	<i>Notts</i>	Worksop, Hodhook ...	·31	13
"	Heathfield, Barklye ...	1·54	57	<i>Derby</i>	Derby, L. M. & S. Rly.	·75	20
<i>Hants.</i>	Ventnor, Roy. Nat. Hos.	1·00	55	"	Buxton, Torr. Slopes	1·41	32
"	Fordingbridge, Oaklands	·05	25	<i>Ches.</i>	Runcorn, Weston Pt. ...	1·00	46
"	Ovington Rectory .....	1·00	40	<i>Lancs.</i>	Manchester, Whit Pk.	1·10	32
"	Sherborne St. John ...	·37	15	"	Stonyhurst College ...	3·17	03
<i>Herts.</i>	Welwyn Garden City...	·47	...	"	Southport, Hesketh Pk	1·70	51
<i>Bucks.</i>	Slough, Upton .....	·70	32	"	Lancaster, Grog Obsy.	2·08	06
"	H. Wycombe, Flackwell	·40	...	<i>Yorks.</i>	Wath-upon-Deane ...	·27	11
<i>Oxf</i>	Oxford, Mag. College...	·74	33	"	Wakefield, Clarance Pk.	·41	10
<i>Nor</i>	Pitsford, Sedgebrook...	...	...	"	Oughtershaw Hall.....	2·51	...
"	Oundle.....	·00	...	"	Wetherby, Ribston H.	·53	19
<i>Beds.</i>	Woburn, Crowthay Mill	·90	39	"	Hull, Pearson Park ...	·52	18
<i>Cam</i>	Cambridge, Bot. Gdns.	1·10	47	"	Holme-on-Spalding ...	·45	...
<i>Essex</i>	Chelmsford, County Lab	·37	17	"	West Witton, Ivy Ho.	·55	19
"	Lexden Hill House ...	·45	...	"	Felixkirk, Mt. St. John	·45	10
<i>Suff</i>	Haughley House.....	·87	...	"	York, Museum Gdns.	·50	20
"	Campan Ashes.....	1·13	57	"	Pleckerling, Hungate ...	·28	11
"	Lowestoft Sec. School	1·02	40	"	Scarborough .....	·41	15
"	Bury St. Ed., Westley H.	1·03	40	"	Middlesbrough .....	·52	19
<i>Norw.</i>	Wells, Holkham Hall	·78	30	"	Baldordale, Hury Res.	1·10	34
<i>Wills.</i>	Devizes, Higholore....	·97	34	<i>Durh.</i>	Ushaw College .....	1·33	40
"	Calne, Castleway .....	1·04	37	<i>Nor</i>	Newcastle, Town Moor	1·70	58
<i>Dor.</i>	Evershot, Melbury Ho.	1·51	48	"	Bellingham, Highgreen	1·72	49
"	Weymouth, Westham ...	·54	25	"	Lillburn Tower Gdns...	1·80	40
"	Shaftesbury, Abbey Ho.	·95	33	<i>Cumb.</i>	Carlisle, Sealby Hall	2·30	50
<i>Devon.</i>	Plymouth, The Hoe ...	1·43	40	"	Borrowdale, Seathwaite	7·00	64
"	Holne, Church Pk. Cott.	1·54	37	"	Borrowdale, Moraine...	8·67	...
"	Teignmouth, Den Gdns.	1·00	48	"	Keswick, High Hill...	2·80	55
"	Oullompton .....	1·29	42	<i>West</i>	Appleby, Castle Bank	2·10	64
"	Sidmouth, Sidmount...	1·54	55	<i>Mon</i>	Aborgavenny, Larch...	·35	12
"	Barnstaple, N. Dev. Ath	1·37	42	<i>Glam.</i>	Ystalyfera, Worn Ho.	1·82	29
"	Dartm'r, Oramere Pool	3·40	...	"	Cardiff, Ely P. Sta.	1·60	37
"	Okehampton, Uplands	1·91	45	"	Trehorbert, Tynyvaun	2·45	...
<i>Corn.</i>	Redruth, Trewigio ...	8·13	92	<i>Carm.</i>	Carmarthen Priory ...	2·01	43
"	Penzance, Morrab Gdn.	1·49	47	<i>Pemb.</i>	Haverfordwest, School	2·39	57
"	St. Austell, Trovarna...	1·97	54	<i>Card</i>	Aberystwyth .....	1·40	...
<i>Soms.</i>	Okeowton Mondip .....	1·97	44	<i>Rad</i>	Birm'W.W. Tynyynydd	1·51	28
"	Long Ashton .....	1·41	40	<i>Mont</i>	Lake Vyrnwy .....	1·60	35
"	Street, Millfield.....	1·00	37	<i>Flint</i>	Sealand Aerodrome ...	1·12	39
<i>Glos</i>	Blookley .....	·67	...	<i>Mor</i>	Dolgelly, Bontlaidu ...	2·27	40
"	Gloucester, Gwynfa ...	1·01	34	<i>Carm.</i>	Llandudno .....	1·44	48
<i>Herc.</i>	Ross, Birchlea .....	·04	25	"	Snowdon, L. Llydaw ...	8·58	...
<i>Salop.</i>	Church Stretton.....	1·08	32	<i>Ang</i>	Holyhead, Salt Island	1·44	45
"	Shifnal, Hatton Grange	1·07	33	"	Lligny .....	2·37	...
<i>Staffs.</i>	Market Dray'tn, Old Sp.	·96	29	<i>Isle of Man</i>			
<i>Worc.</i>	Ombersley, Holt Look	·81	30	"	Douglas, Boro' Cem. ...	1·22	31
<i>War.</i>	Aleicester, Ragley Hall..	·70	25	<i>Gwynsey</i>			
"	Birmingham, Edgbaston	·77	28	"	St. Peter P't. Grange Rd	1·51	64

## Rainfall: August, 1933: Scotland and Ireland.

Co.	STATION	In.	Per- cent of Av.	Co.	STATION	In.	Per- cent of Av.
<i>Wig.</i>	Pt. William, Monreith	1.93	50	<i>Suth.</i>	Melvieh	3.99	134
	New Luce School	3.43	77		Loch Moro, Aelfary	11.04	180
<i>Kirk.</i>	Dalry, Glendarroch	2.35	49	<i>Caith.</i>	Wick	2.57	08
	Carrphairn, Shiel	3.98	89	<i>Ork.</i>	Doorness	2.12	74
<i>Dumf.</i>	Dunfries, Cleithon, R.I.	1.58	41	<i>Shet.</i>	Lerwick	3.04	121
	Esksdalemuir Obs.	2.85	55	<i>Cork.</i>	Cahernagh Rectory	2.20	...
<i>Rozb.</i>	Bransholm	1.07	52		Dunmanway Rectory	2.30	49
<i>Selk.</i>	Ettrick Manse	2.10	41		Cork, University Coll.	1.64	40
<i>Perb.</i>	West Linton	2.17	...		Ballinacura	.80	24
<i>Berw.</i>	Marchmont House	1.48	45	<i>Kerry.</i>	Valentin Obs.	4.17	87
<i>E. Loth.</i>	North Berwick Res.	.80	25		Garrahameen	0.10	80
<i>Midl.</i>	Edinburgh, Roy. Obs.	.84	20		Darrynane Abbey	2.00	48
<i>Lan.</i>	Auchtyfardle	2.33	...	<i>Wat.</i>	Waterford, Gortmore	1.02	27
<i>Ayr.</i>	Kilmarnock, Kay Pk.	3.20	77	<i>Tip.</i>	Nonagh, Oss. Lough	1.71	43
	Girvan, Pilmore	3.44	77		Rosera, Timoney Park	1.93	...
<i>Renf.</i>	Glasgow, Queen's Pk.	2.61	74		Cashel, Ballinamona	2.15	61
	Greenock, Prospect H.	3.51	65	<i>Lim.</i>	Foynes, Coolmaues	1.70	46
<i>Bute.</i>	Rothsay, Ardenoraig	4.58	...		Castlecounel Rec.	1.51	...
	Dougarie Lodge	4.07	...	<i>Clare.</i>	Inagh, Mount Callan	4.05	...
<i>Arg.</i>	Ardgour House	10.95	...		Broadford, Hurdlest'n	2.12	...
	Glen Elvie	...	...	<i>Wexf.</i>	Gorey, Courtown Ho.	.00	80
	Oban	5.23	112	<i>Kilk.</i>	Kilkenny Castle	1.91	55
	Poltalloch	5.03	121	<i>Wick.</i>	Rathnew, Clonmannon	.70	...
	Inveraray Castle	8.28	120	<i>Carl.</i>	Hacketstown Rectory	1.04	26
	Islay, Ballabru	4.43	102	<i>Lein.</i>	Blandsfort House	1.05	40
	Mull, Benmore	17.00	...		Mountmellick	2.29	...
	Tiree	...	...	<i>Offaly.</i>	Birr Castle	2.33	61
<i>Kinn.</i>	Loch Leven Sluice	.93	24	<i>Dublin.</i>	Dublin, FitzWm. Sq.	.61	20
<i>Perth.</i>	Loch Dhu	5.10	70		Balbriggan, Ardglillan	1.02	30
	Balquhiddie, Stronvar	2.76	...	<i>Meath.</i>	Beaupare, St. Cloud	2.00	...
	Orkist, Strathearn Hyd.	1.23	20		Kells, Headfort	1.34	32
	Blair Castle Gardens	1.51	45	<i>W.M.</i>	Moate, Coolatora	2.34	...
<i>Angus.</i>	Kuttis School	.85	23		Mullingar, Belvedere	1.93	46
	Pearse House	1.41	...	<i>Long.</i>	Castle Forbes Glens	2.10	51
	Montrose, Bunnyside	...	...	<i>Gal.</i>	Galway, Grammar Sch.	...	...
<i>Aber.</i>	Braemar, Bank	1.09	32		Ballynahinch Castle	0.61	120
	Logie Coldstone Sch.	.75	24		Ahascragh, Clonbrook	2.24	58
	Aberdeen, King's Coll.	1.22	45	<i>Mayo.</i>	Blackrod Point	5.54	121
	Pyrie Castle	1.15	36		Mallananny	0.38	...
<i>Moray.</i>	Gordon Castle	1.56	40		Westport House	3.59	80
	Grantown-on-Spey	...	...		Dolphin Lodge	1.07	128
<i>Nairn.</i>	Nairn	...	...	<i>Sligo.</i>	Markree Obay	3.05	71
<i>Inver's.</i>	Ben Alder Lodge	3.00	...	<i>Ferm.</i>	Enniskillen, Portora	...	...
	Kingussie, The Birches	1.32	...	<i>Arm.</i>	Armagh Obay	1.63	42
	Inverness, Oldduthel R.	1.77	...	<i>Down.</i>	Fosunny Reservoir	3.74	...
	Loch Quoich, Loan	5.65	...		Seaford	2.16	58
	Glenquoth	10.61	123		Donaghadee, C. Stn.	2.25	68
	Arisaig, Fairo-na-Sguir	5.01	...		Banbridge, Milltown	1.53	44
	Port William, Glasdrum	6.10	...	<i>Antr.</i>	Belfast, Cavell Rd.	2.03	...
	Skye, Dunvogan	7.55	...		Aldergrove Aerodrome	2.70	77
	Barra, Skallary	...	...		Ballymena, Harryville	2.78	65
<i>R &amp; O.</i>	Alnoss, Ardrross Castle	1.53	52	<i>Lon.</i>	Garvagh, Moneydig	2.33	...
	Ullapool	5.52	155		Londonderry, Oreggan	3.24	70
	Achnashellach	0.50	98	<i>Tyr.</i>	Omagh, Edensel	2.30	56
	Stornoway	6.08	153	<i>Don.</i>	Malin Head	3.75	...
<i>Suth.</i>	Lairg	2.52	79		Millford, The Manse	2.49	50
	Tongue	4.78	149		Killybegs, Rockmount	3.85	...

## Climatological Table for the British Empire, March, 1933

STATIONS	Mean of Day of M.S.L.	Diff. from Normal	Absolute		Mean Values			Mean	Relative Humidity	Mean Cloud Amt.	Days	Diff. from Normal	Hours per day	Per cent. age of possible	SUNSHINE
			Max.	Min.	Max.	Min.	Diff. from Normal	Wet Bulb							
	mb.	mb.	° F.	° F.	° F.	° F.	° F.	° F.	%	0-10	in.	in.			
London, Kew Obsy.	1014.1	+ 0.7	63	28	54.5	37.9	+ 3.8	38.6	88	5.7	12	+ 0.48	5.7	49	
Gibraltar	1018.9	+ 1.8	70	47	64.5	51.0	+ 0.3	51.3	86	5.3	14	+ 0.21	5.3	44	
Malta	1017.3	+ 3.1	66	46	60.1	56.3	+ 0.8	56.8	76	7.5	8	+ 1.28			
St. Helena	1011.2	- 0.5	73	61	70.2	62.9	- 0.2	63.0	91	8.7	20				
Freetown, Sierra Leone	1012.0	+ 1.3	92	72	89.3	76.3	+ 0.4	76.5	83	4.5	2	+ 0.95			
Lagos, Nigeria	1009.4	+ 0.5	93	73	89.4	79.0	+ 0.8	78.0	83	8.5	4	+ 0.92			
Kaduna, Nigeria	1009.3	- 2.6	99	61	95.3	63.7	+ 0.9	66.2	50	4.0	1	+ 0.20			
Zomba, Nyasaland	1009.6	- 0.1	87	59	80.0	64.6	+ 1.0	67.2	76	6.8	16	+ 0.60			
Salisbury, Rhodesia	1011.7	+ 0.1	35	50	81.0	57.0	+ 0.8	61.3	67	3.8	4	+ 4.36			
Cape Town	1015.2	+ 0.7	90	50	74.9	57.7	- 1.8	57.7	78	4.2	4	- 0.51			
Johannesburg	1011.8	+ 0.2	84	45	77.3	56.5	+ 3.7	56.0	60	3.9	11	+ 0.69			
Mauritius	1011.7	- 0.3	87	70	88.1	73.2	+ 0.2	73.4	78	6.6	23	+ 1.89			
Calcutta, Alipore Obsy.	1009.8	- 0.1	100	59	93.3	70.6	+ 1.7	70.6	80	1.9	0*	- 1.32			
Bombay	1010.1	- 0.8	100	69	88.2	73.0	+ 1.1	71.1	70	0.6	0*	- 0.02			
Madras	1010.7	- 0.2	89	65	86.6	71.4	- 2.1	74.9	85	3.5	3*	+ 3.08			
Colombo, Ceylon	1010.1	- 0.0	89	69	87.2	73.6	- 1.4	78.6	74	5.0	4	+ 1.88			
Singapore	1009.0	- 0.7	92	68	87.7	80.3	- 0.9	77.0	90	5.4	20	+ 3.57			
Hongkong	1016.1	+ 0.1	82	48	69.6	59.7	+ 1.4	59.5	75	8.7	9	+ 1.93			
Sandakan	1009.8	..	88	71	85.9	75.0	- 0.5	76.7	84	7.6	19	+ 5.35			
Sydney, N.S.W.	1013.8	- 2.5	90	49	74.5	63.6	- 0.2	64.6	74	6.6	13	- 2.72			
Malbourne	1013.7	- 3.2	92	43	75.8	53.1	0.0	57.6	60	4.8	7	- 0.69			
Adelaide	1014.9	- 2.2	97	44	78.6	57.6	- 1.7	57.8	47	5.7	7	+ 0.80			
Perth, W. Australia	1013.9	- 1.4	101	50	81.3	61.7	+ 0.3	62.8	66	3.8	6	+ 0.34			
Ootgardie	1013.6	- 1.2	103	41	85.9	58.6	+ 0.4	58.7	49	4.7	5	+ 0.10			
Brisbane	1012.1	- 2.3	97	61	85.3	68.1	+ 2.4	69.1	66	5.9	6	+ 5.22			
Hobart, Tasmania	1010.1	- 4.1	87	40	68.4	49.9	- 1.2	51.3	63	5.8	15	+ 0.41			
Wellington, N.Z.	1016.5	- 0.7	76	44	68.3	54.9	+ 1.0	57.3	71	6.5	5	+ 1.23			
Suva, Fiji	1008.1	- 0.3	91	72	86.3	75.3	+ 0.7	76.9	84	7.0	28	+ 18.60			
Apia, Samoa	1008.9	- 0.3	88	72	85.3	74.3	+ 0.5	77.1	81	7.3	22	+ 2.57			
Kingston, Jamaica	1014.2	- 0.7	91	66	86.1	69.1	+ 0.5	67.3	79	4.2	6	- 0.20			
Grenada, W.I.	1015.2	- 2.1	..	..	..	..	..	..	..	..	..	..			
Toronto	1015.2	- 2.1	50	9	36.6	26.6	+ 2.0	27.0	70	7.0	8	+ 1.19			
Winnipeg	1020.4	+ 1.2	48	-19	27.4	6.8	+ 2.1	..	..	4.3	1	- 0.96			
St. John, N.B.	1010.5	- 3.6	46	4	34.7	21.1	- 0.5	22.8	75	6.0	5	+ 1.95			
Victoria, B.C.	1015.4	- 0.5	55	34	48.7	39.3	+ 0.5	40.6	48	7.1	15	- 0.53			

<h1 style="margin: 0;">The Meteorological Magazine</h1>	
	<p><b>Vol. 68</b></p> <p><b>Oct. 1933</b></p> <p><b>No. 813</b></p>
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## The Memorable Summer of 1933

The summer of 1933 provided unusually frequent periods of fine, warm weather, among the most notable being June 1st to 8th, July 1st to 7th, and 18th to 27th, and August 1st to 8th and 26th to 30th. Early in June conditions in the eastern districts of England were governed by a continental anticyclone which, by the 4th, had extended its influence over the whole country. The fair spells in July and August were due to the passage eastward or north-eastward of anticyclones situated initially off our south-west coasts. The system which was centred over northern Ireland on July 4th is worthy of mention since the reading at Malin Head at 1h. (1037.9 mb.) has not been equalled in the summer in the British Isles since July 11th, 1911. It is significant that all the cases of highest temperature (90° F. or above) in the midland and eastern districts of England occurred when the anticyclone had moved to central Europe or the southern Baltic. On the record hot day of August 9th, 1911, the synoptic chart also shows an anticyclone centred over the southern Baltic. Monthly mean pressure was well below the normal in June, 1933, but above normal in July and August except in the north of Scotland.

In Scotland, July was the warmest month of that name for over thirty years, August the warmest since 1911, while the exceptional warmth of June may be illustrated by the fact that

the mean monthly temperature (0-24hr.) at Aberdeen was the highest for June since observations were begun in the north wall screen in 1869. At Eskdalemuir Observatory (Dumfriesshire) there were eight days during the three months with a maximum temperature above  $77^{\circ}$  F., the previous largest number in any year back to 1911 being three in 1921 and 1925. In England the remarkable warmth may be illustrated from the London observations. At Greenwich the mean temperature for the three months June to August,  $64.6^{\circ}$  F., has only three times been slightly exceeded since 1841, viz.  $65.0^{\circ}$  F. in 1859,  $65.1^{\circ}$  F. in 1868 and  $64.8^{\circ}$  F. in 1911, while the mean minimum temperature for the three months,  $54.5^{\circ}$  F., has only been exceeded twice, in 1846 and 1859. The following table gives the number of days at Kew Observatory with high maximum temperatures during the period June to August in warm summers since 1901:—

TABLE I.—FREQUENCY OF WARM DAYS AT KEW.

	1901	1904	1906	1911	1914	1919	1921	1923	1925	1929	1932	1933
No. of days with max. temp. above $77^{\circ}$ F.	17	15	14	35	18	12	23	20	18	13	12	32
No. of days with max. temp. above $80^{\circ}$ F.	1	0	1	7	1	0	3	4	0	1	2	3

The table shows how exceptionally frequent were the warm days during the summer of 1933. The persistently warm nights were as notable as the unusual number of hot days.

Rainfall was deficient during each of the three months in England and Wales and Ireland. In Scotland there was an excess in July. It was the driest August in England and Wales since 1818, but Table II shows that for the summer as a whole the years 1887 and 1921 were drier, while as far as can be ascertained at present 1911 was about equally dry.

TABLE II.—RAINFALL FOR ENGLAND AND WALES.

(Percentage of Average, 1881-1915.)

Year.	June.	July.	August.	Mean of 3 months.
1887	...	30	59	65
1911	...	124	23	66
1921	...	18	44	116
1929	...	78	87	84
1933	...	92	82	38

The years 1921 and 1929 were much more remarkable with regard to deficiency of rainfall if the eight months January to August are considered in place of June to August.

In Scotland rainfall was more variable, July being notably wet in the south and August in the west and north-west, while locally in eastern districts August was the driest on record. Over Ireland as a whole rainfall for each month was below the

normal, the deficiency being greatest in August. At Phoenix Park, Dublin, August, 1933, was drier than any previous August since records were begun in 1877, apart from the equally dry one of 1913. At individual stations in England and Wales all three months were notably dry; for example, the mean of the percentages of the normal for the three months was only 36 at Wath-upon-Deane (Yorkshire), and 39 at Scarborough and Chelmsford.

In spite of the general deficiency of rainfall, thunderstorms were frequent, notably so in June, thunder occurring somewhere in the British Isles during this month on no fewer than twenty days. At Copdock (Suffolk) the observer reported thunderstorms on seven consecutive days, which is unique in his 33 years' experience, and at Kew Observatory the number of days of thunder was one more than the previous June record for the period 1881-1932.

The summer was not only exceptionally warm and dry but markedly sunny. The percentage of the normal sunshine for

TABLE III.—SUNSHINE IN HOURS FOR THE PERIOD  
JUNE TO AUGUST.

Station	1890	1901	1905	1906	1911	1921	1933	Average 1881- 1915
Stornoway	541	494	560	415	540	431	488	456
Aberdeen	560	590	528	514	632	514	588	493
Edinburgh	—	615	590	547	641	538	571	501
Markree Castle	496	384	495	459	565	472	466	433
Armagh	540	439	529	511	597	477	474	447
Valentia	627	402	491	503	636	588	446	502
Worthing	889	804	648	792	900	774	837	682
Southampton	878	736	601	756	842	709	753	636
Jersey	928	831	663	797	922	761	847	723
Falmouth	883	689	582	684	850	723	689	657
Bath	—	646	575	711	824	573	712	606
Kew	760	695	563	734	789	647	753	585
Oxford	776	672	554	719	744	650	708	576
Cambridge	724	773	609	715	777	657	707	591
Blackpool	639	682	692	680	800	617	646	612
Harrogate	—	725	681	578	654	568	627	537

the British Isles excluding the north of Scotland and the Channel Isles is 114. Many stations in England enjoyed more than 100 hours in excess of the normal during the period June to August, and in south-east England many recorded more than 150 hours in excess. Table III gives totals for the three months at a selection of stations for some of the sunniest years since 1899. The year 1905 is included because of the good totals in the west and north. It will be seen that the 1921 records were



exceeded in 1933 at most stations, but that the figures of 1911 were not equalled. At Valentia Observatory in south-west Ireland the total for the summer of 1933 was substantially below the normal. Days with no sunshine were notably rare. Statistics have been examined back to 1913 for a selection of stations throughout the British Isles. It was found that for the months June to August, out of 14 stations examined, so few sunless days had not been recorded at five stations, while at another five, although the number of days was equally small in one or two years, it was never smaller.

L. F. LEWIS.

The charts of deviations of pressure from normal over the northern hemisphere show that the weather of Europe has been more or less dominated by high-pressure systems throughout the first nine months of 1933. The location of the centre has, however varied greatly. In January there was a great westward extension of the Siberian anticyclone across northern Europe, pressure being 10 mb. above normal at Waigatz and 13 mb. at Moscow. The excess of pressure included the British Isles, where the weather was on the whole cold and bright, though an exceptionally intense Icelandic low made itself felt from time to time. In February the greatest excess of pressure lay between Iceland and Greenland (+15 mb.), and included most of the British Isles; our weather was again bright and on the whole mild, but with one noteworthy snowstorm. In March a centre of excess pressure lay over central Europe, but the British Isles came under the influence of a stormy area on the Atlantic.

In April the deficit of pressure over the Atlantic was maintained, but the high-pressure area moved westward to include France and the British Isles, most of these countries having an excess of more than 5 mb. Pressure was low in Russia but high in Canada, Greenland, Iceland and the Mediterranean; an anticyclonic belt extended from Greenland to North Africa across the British Isles and almost completely barred the passage of depressions until the 22nd. On this date the belt of high pressure gave way and a trough of low pressure extended from west to east. The break was, however, only temporary, and throughout May the British Isles was a no-man's land between areas with pressure above normal over Scandinavia and the Mediterranean and areas with pressure below normal over the Atlantic and Russia. On the whole the month was dry but towards the end especially the pressure distribution became rather uniform and unstable, a type suitable for thunderstorms which became notably frequent in the last part of May. In June there was a general fall of pressure over western Europe, the deficit exceeding 3 mb. in northern France, but pressure was again high over the North Atlantic, and in spite of an

abnormal number of thunderstorms (see *Meteorological Magazine* for June, p. 129) and some heavy individual falls, the general rainfall was again below normal.

In July the Atlantic anticyclone spread over Europe, where pressure was generally above normal, but the British Isles came under the influence of several secondaries from a depression over Iceland, and it was not until August that anticyclonic conditions became persistent, though not intense. In September they became far more marked, but the anticyclonic centre lay to the north-eastward of the British Isles. In southern England conditions were considerably affected by an area of low pressure over France and the Bay of Biscay.

Considering the period as a whole, we find that the mean pressure from April to September inclusive was slightly above normal over the British Isles, Scandinavia, the whole of western and central Europe and the Mediterranean. The excesses nowhere exceeded 2.5 mb, however; considering the general dryness much more definitely anticyclonic conditions would have been expected. The explanation seems to be that while most of Europe was under the influence of fairly persistent anticyclones, the high-pressure centres were for the most part just outside the borders of Europe. From the limited data available at present, it seems probable that the deficit of rainfall included Scandinavia and western Europe as well as the British Isles, while temperatures were above normal in Scandinavia and the British Isles but only normal in central and southern Europe.

## The Sunshine Records of the North and South Compared

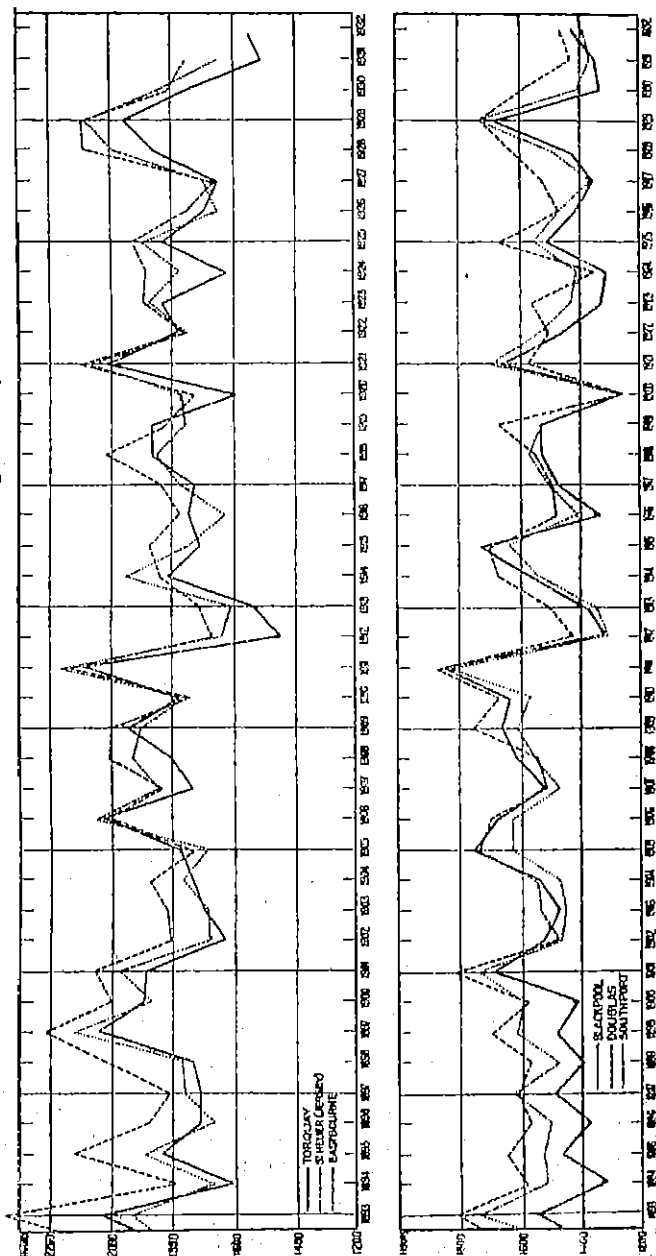
*Is there a Four-Year Cycle in our Periods of good and bad Weather?*

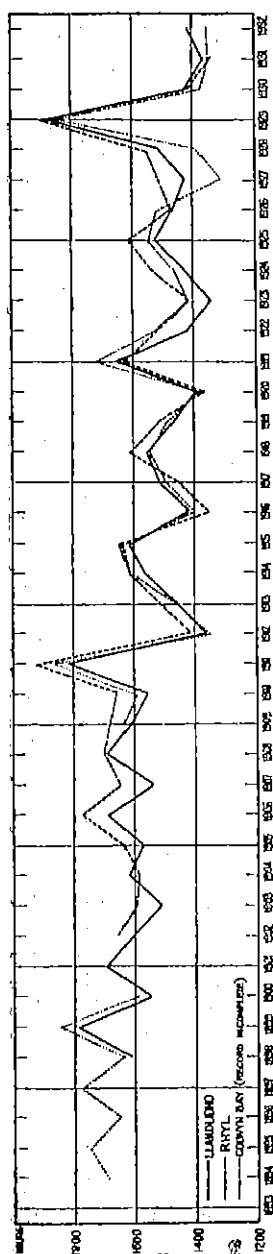
By JOHN B. C. KERRISAW, F.I.C.

The writer had occasion recently in connexion with his work for the Smoke Abatement movement in the north, to study by graphic methods the official sunshine records of some of our leading seaside resorts. This examination of the official figures has brought to light one remarkable feature which no other observer has so far noted, namely, that there is a three-and-a-half, or four-year cycle, in the return of good summers, and this periodic variation can be traced back so far as the returns have been examined. It must be noted, however, that the Campbell-Stokes Sunshine Recorder had not come into general use until after 1896, and that the totals recorded before and after that date are not comparable.\*

\* Mr. Buxendell informs me that the earlier figures at Southport were obtained by a different type of recorder which gave totals 4 per cent higher than the Stokes instrument; and the Southport figures for 1892 to 1896 have been corrected accordingly before using in the diagram.

## ANNUAL SUNSHINE RECORDS

*reproduced by the courtesy of Mr. J. B. C. Kershaw*



It is now quite established that there is a sunspot cycle which varies between eleven and thirteen years, and that this cycle does exert an influence upon our records of sunshine. During the last forty years, 1899, 1911, 1921 and probably 1933 have been the years of minimum sunspot activity, and these have all been marked by very high totals of sunshine in this country. The prospects of another very high total during the present year are certainly favourable, since the totals of the earlier maximum years have been passed for the first eight months, and if we have a fine autumn, which is probable, the very high sunshine totals of the years 1911 and 1929 will be exceeded by those of 1933.

In the series of diagrams printed opposite, the annual figures of hours of sunshine of nine of the leading seaside resorts, in the north and south, have been plotted for the forty-year period extending from 1893 to 1932. It will be seen that in each of these nine places, there has been a three- to four-year cycle in the returns of high sunshine figures, especially marked in the period since the end of the war, and the only exceptions have been at the dates when the eleven-year sunspot period clashed with the shorter periodicity. Another feature of the curve is, that the years of very high sunshine totals are in nearly all cases followed by a sudden drop of the curve in the succeeding year, and this is followed by a gradual ascent extending over two or three years, to the next peak year.

The causes of this three-and-a-half to four-year period are probably of solar origin, but as the observations have been made so recently they have not yet been discussed by expert meteorologists. In a later article, the writer proposes to discuss observations he is making upon the influence of the Smoke Abatement movement upon the

sunshine records, in order to determine how far the improvement noticeable in the atmosphere in London and other large towns and cities, is being shared by the surrounding districts of the country.

Thanks are due to Mr. J. Baxendell, the Corporation Meteorologist of Southport and to the Meteorological Office for supplying many of the official figures of sunshine duration upon which the diagrams are based.

### Discussions at the Meteorological Office

- The subjects for discussion for the next two meetings will be:—  
 October 30th, 1933.—*The mechanism of the great burst of cold air at the end of November, 1930.* By E. Ekhart (Beitr. Geophys., Leipzig, **38**, 1933, pp. 282-308) (in German).  
*Opener*—Mr. H. W. L. Absalom, B.Sc.  
 November 13th, 1933.—*American air mass properties.* By H. C. Willott (Cambridge, Mass., Papers in meteorology, **2**, No. 2, 1933). *Opener*—Capt. F. Entwistle, B.Sc.

### OFFICIAL PUBLICATION

The following publication has recently been issued:—

**Annual Report of the Director of the Meteorological Office presented by the Meteorological Committee to the Air Council for the year ending March 31, 1933.**

The chief item of interest in this report concerns the British participation in the Second International Polar Year. From August, 1932, to August, 1933, expeditions sent by 14 countries have been stationed in various polar regions; a British party which includes four members of the Office staff has occupied a station at Fort Rae in north-west Canada making observations of meteorology, terrestrial magnetism and aurora.

The demands for meteorological information both by Government departments and the general public continued to increase; and with the increase of civil and private flying there was naturally an increase in the number of demands for information for aviation. Special arrangements were made for the supply of information to the *Graf Zeppelin* during its visit to this country in July, 1932; and a special meteorological organization was brought into operation for supplying information to the pilots of the Fairey-Napier monoplane for the non-stop flight from England to Walvis Bay in February, 1933.

### Correspondence

To the Editor, *The Meteorological Magazine*.

#### Cloud

In connexion with Mr. Wooldridge's letter in the September

issue, I venture to forward for comparison some data for a southern station, Grayshott. Observations have been taken at 9h. daily, and the period examined is from 1901-32.

As at Market Harborough, the lowest monthly mean was in July, 1911, the amount being 3.2. On five other occasions has the amount been less than 4, the last being 3.8 in June, 1925. Cloud amount 5 or lower has occurred during the period considered at least once in all the months March-October.

The most interesting result of the investigation is, however, in connexion with high monthly means. The highest is 8.7 in April, 1920. After this comes 8.6 in February, 1926. Cloud amount 8 or more has occurred at least once in every month except September and November. The absence of high cloud means in November is a curious result, as is also the high value of 8.5 in a summer month, June, 1909.

S. E. ASHMORE.

22, Soho Road, Handsworth, Birmingham, 21. October 1st, 1933.

### Luminous Night Clouds

On reading the letter with the above title on p. 186 of the *Meteorological Magazine*, I wondered whether the cloud formation described therein would throw any light on a hitherto rather obscure passage in Beddins' life of St. Wilfred (634-709), Archbishop of York and Apostle of Sussex. The passage, as rendered by Colgrave is as follows:—"Chap. LXVIII. The sign of the bow.

"On the anniversary of our holy bishop . . . when the feast which accompanied the solemnity was over the abbots went out with the whole community to compline in the evening twilight. Suddenly they saw a wonderful sign in the sky, namely, a white arc, surrounding the whole monastery like a rainbow by day but without its various colours. For this white arc starting from the gables of our church dedicated to S. Peter (now Ripon Cathedral) opposite where the limbs of our holy bishop rest and stretching southward made a wide sweep round the right-hand side of the monastery until it reached the north. Then continuing towards the south-east quarter of the morning sky and tending upwards it ended there. We worshipped and praised the Lord . . . . ."

Both aurora and lunar rainbows have been suggested as an explanation of this "sign," but Colgrave rules both suggestions out. It is tempting to see therein, a perhaps glorified description, of some cloud phenomenon as described by Mr. Horrex:

CICELY M. BOTLEY.

Guildables, 17, Holmesdale Gardens, Hastings. September 20th, 1933.

### On the Temperature of Rain

In the July issue of the *Meteorological Magazine* Colonel E. Gold

briefly discusses from a theoretical standpoint the interesting question of the temperature of rain and arrives at the conclusion that "apart from evaporation, even the largest drops will warm up practically to the air temperature; the net result when evaporation is taken into account will, therefore, be a temperature not very far from the wet-bulb temperature . . . ." I wish to mention here that the existing records of the temperature of rain, so far as my information goes, generally support the above conclusion. The observations of Schlagintweit ("Neue Untersuchungen") on Vincenthütte showed that the temperature of rain was sometimes slightly higher, sometimes slightly lower than the temperature of air. The numerous measurements of Breitenlohner at Lobositz and of Arendt at Potsdam\* during thunderstorms showed that the temperature of rain was 3°C. to 0.8°C. lower than that of air. Passerini†, who made a number of measurements of the temperature of rain, also obtained more or less the same result.

In general, therefore, experimental data show that the temperature of rain is slightly lower than the temperature of air. It may be remarked, however, that a distinction should be made between frontal rain and the rain associated with thunderstorms, the temperature of the latter type of rain being more likely to be lower. If the rain is accompanied by hail or snow, the temperature can sometimes be very low. In most cases, therefore, the cooling of air directly by rain should not exceed about 3°, and would often be considerably less. One factor that would tend to reduce the cooling effect of rain is the heat developed due to friction between the falling raindrops and the surrounding air which would be quite appreciable at least in moist air with a weak temperature gradient. Another factor which would probably have an opposing effect is the absorptive action of the falling rain on the air through which it falls. The falling raindrops would adsorb air from the higher levels and liberate it in the lower levels; the adsorbed air will not, most probably, be dynamically heated up as it is brought down by the rain and will therefore tend to cool the air in the lower levels.

A. K. DAS.

*Alipore Observatory, Calcutta. September 1st, 1933.*

### Waterspout in Kirkwall Bay

Mr. J. Crichton sends us some notes by Mr. J. Muir, the Observer at Kirkwall, and a cutting from *The Orcadian*, describing a waterspout which occurred in Kirkwall Bay, Orkneys, on August 21st. During the morning heavy thundery clouds lay to the north of Kirkwall. Shortly after 11 a.m. a whirling

\* *Wetter, Berlin* xii, 1895, p. 62.

† *Torino, Boll. Mens. Soc. Meteor. Ital.* xiv, 1894.

funnel-shaped cloud grew downwards from this mass of storm cloud, tapering towards the water surface. The surface of the sea was violently agitated, and the spray was estimated to have risen to a height of more than twenty feet. The spray resembled smoke and the volume was so great that it was mistaken by several spectators for smoke from a burning motor-boat.

The waterspout moved towards the south-west at a speed estimated at about 20 miles per hour. It broke up just off the Quanterness shore, to the west of Kirkwall Bay, but about an hour later there was a cloud-burst at Dounby, 11 miles to the west-north-west of Kirkwall. For about half an hour the rain "stopped pouring and simply gushed."

The waterspout was preceded and followed by peculiar optical phenomena. Mr. Muir writes: "There was reported to me by the crew of a steamer that they saw a perfectly circular rainbow brightly coloured and perfectly complete about 8h. the same morning. I questioned them closely about it and I am convinced they actually saw it, but it lasted only a short time." This would seem to have been some sort of halo. Another phenomenon occurred after the waterspout had passed. One observer stated: "I observed a strange bright light in the sky, almost as brilliant as lightning, though of course, it was not a flashing light." Two others said that after the spout had passed into the Bay of Firth, towards Quanterness, they saw two rainbow-coloured bands stretching horizontally across the horizon.

A possible explanation of these horizontal bands is that they were the summits of the arcs of rainbows, the greater part of which would be below the horizon. At 11.15 a.m. B.S.T. on August 21st in the latitude of Kirkwall, the highest part of the arc of a primary bow would be only about  $4^{\circ}$  above the horizon, and would appear, as described, almost as a horizontal band.

Another waterspout was observed on the afternoon of September 23rd over Eday Sound, Orkneys. The observer at Kirkwall states, "it seems strange that we have had two this year and, so far as I have read or heard have heard no mention of them before. None of the local writers of the past made any mention of them."

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### Remarkable Thunderstorm at Shanklin

We had a rather remarkable thunderstorm at Shanklin, Isle of Wight, last Tuesday evening, September 26th.

It had been thundery all Tuesday, but towards sunset the sky became clear and I thought the electrical disturbance was passing off. About 9 p.m., however, it became heavy and clouded over, and soon after 9.30 p.m., distant thunder and lightning occurred in the north-east away over Culver Cliff. Very soon the storm worked its way towards Shanklin and broke



fair and square about 10 p.m. with vivid lightning and loud thunder accompanied by heavy rain. About 10.30 p.m., the rain ceased, and the lightning and thunder eased off, and for about 10 minutes there was a complete cessation, the air being very still and the sky heavily overcast. Then without any warning a terrific flash of ball lightning rent the sky just east-south-east of the town, followed immediately by the loudest and most terrifying crack of thunder I have ever heard, either in England or the tropics. Not a drop of rain fell and that ended the storm entirely, no further rain, thunder or even sheet lightning occurring.

J. E. COWPER.

*The Plough and Harrow Hotel, Edgbaston, Birmingham. October 3rd, 1933.*

### Heavy Rainfall at Fleet, near Aldershot, September 26th, 1933

The intense thunderstorm rain which occurred during the evening of September 26th is of special interest, not only because of the large amounts recorded, but also because of its occurrence late in the year. Usually about two-thirds of the total number of intense falls which qualify for special mention in *British Rainfall* occur in the three months June, July and August. Mrs. L. M. Kent, of Fleet, drew attention to the storm in a letter to *The Times* of September 29th. The largest measurements were:—

Fleet (Home Wood) ... ..	5.14 in.
Crookham ... ..	4.25 in.
Winchfield (The Chase) ... ..	4.02 in.
Hartley Wintney (Council Offices) ...	3.90 in.

At Fleet the rain is reported to have fallen between 15h. and 19h.,\* at Winchfield Major R. E. Fryer gives between 15h. 30m. and 19h. 30m., while the Sanitary Surveyor and Inspector at Hartley Wintney gives the following details:—"Light rain commenced to fall at 15h. 30m., heavy rains accompanied by very heavy thunder and vivid lightning continued incessantly from 16h. to 18h. 20m. There was a cessation for 10 to 15 minutes when heavy hail followed again by heavy rains continued until 19h. 35m. Light rain fell until 19h. 40m., after which there was nothing beyond a slight drizzle."

At South Farnborough, four miles east of Fleet, the total rainfall was only 0.30 in. So far as can be ascertained more than four inches fell over about 8 sq. miles, and more than three inches over about 21 sq. miles. The whole of this rain occurred within 4½ hours. Comparable intense rains are those of July 24th, 1904, near Huddersfield, October 20th to 21st, 1908, near Portland Bill, and August 18th, 1924, near Cannington. On each of these occasions the intense rain lasted about five hours and the

\* All times are G.M.T.

areas with more than four inches were about 7, 11 and 10 sq. miles respectively.

Thunderstorm rains occurred over a wide area in the south of England on September 26th. More than two inches was recorded at Bramley to the north and at Hoddington House to the south of Basingstoke, while as much as 4.31 inches fell at Monkton Park near Chippenham. Heavy rain occurred from 15h. to about 17h. but subsequently there was another storm lasting about 10 minutes.

J. GLASSPOOLE.

### Degree of Accuracy in Estimating Tenths

*Apropos* the note under the above title in the *Meteorological Magazine*, September, 1933, p. 191, I have two sets of observations which may be of interest.

(1) Mr. C. J. Boyden, of this Office, and I once made an experiment on ourselves, similar to that described in the above note. Centimetre scales were drawn, and in each centimetre a transverse mark was made. The intervals were estimated to two decimal places (*e.g.*, 0.47), and afterwards measured with a half-millimetre scale, the second decimal place being estimated. For 100 readings, taking the measured values as correct, my mean error (irrespective of sign) was 0.018, and I find that I too tended to under-estimate values below 0.5 and over-estimate those above 0.5. Mr. Boyden beat me, having a mean error of .011 for 50 readings, and his errors were practically uniformly distributed. Our estimates were made with extreme care, and I believe we used a pen or pencil as a pointer to help in mentally subdividing the intervals. A set of readings made in the course of an ordinary day's work would probably be much less accurate. One does not, of course, usually estimate to two decimal places.

(2) Some time ago I was dealing with tabulated hourly readings, in which the curves are measured with a millimetre scale, the readings being estimated to tenths of a millimetre. I happened to notice that the figure 7 was very rare in the decimal place, and this led me to count the number of times that each figure from 0 to 9 occurred in the decimal place in two months' tabulations (about 1,500 readings). The result was as follows:—

Figure	0	1	2	3	4	5	6	7	8	9
Percentage frequency	32	10	7	6	4	3	4	1.4	7	20

Another two months, about two years later in date, gave the following result:—

Figure	0	1	2	3	4	5	6	7	8	9
Percentage frequency	27	14	13	5	3	2	6	1.8	11	18

In the first year 68 per cent., and in the second 59 per cent. of the readings ended in 0.9, 0.0 or 0.1. It is obvious that the frequency of each figure ought to be 10 per cent. How much

variation is to be expected with the given number of readings I am not prepared to say, but it seems that there might have been a gain in accuracy on the average by reading to the nearest half millimetre, making all readings end in 0.0 or 0.5.

This has a bearing on the question of units in meteorology, and suggests that it is better to choose a unit of suitable size and read to whole numbers than to have a larger unit and read to decimals. I ought to say that in the case quoted it was thought that the scale used and the method of measuring were not very suitable and might have been responsible for some inaccuracy, and that in tabulations of another kind (anemograms) the same tabulator tended, in common with another, merely to emphasize slightly the figures 0 and 5. No doubt most of us would be guilty of a certain degree of favouritism. But the fact remains that the first tabulations show a bias great enough to make the decimal figure practically meaningless.

D. N. HARRISON.

*Meteorological Office, 6, Drumshough Gardens, Edinburgh, 3. October 3rd, 1933.*

## NOTES AND QUERIES

### Report on Ascents Carried Out at Shoburyness with Large Pilot Balloons

Towards the end of August three large pilot balloons were obtained for experimental purposes, and this note gives particulars of interest concerning each of these ascents. The three balloons were by Pirelli and were extremely well made, and all weighed 735 grams to the nearest gram. They all bore date August 10th, 1933. One of the objects kept in mind in making these ascents was the value of the number  $q$  which appears in the formula connecting the rate of ascent of pilot balloons with their weight and free lift. Simultaneously with each ascent of a large balloon, therefore, an ascent with a 90-inch pilot balloon was carried out with two other theodolites. In this way a check could be secured upon the vertical movements of the atmosphere. Fortunately on all three occasions vertical motion was very small and the rates of ascent for the large balloons can be considered as reasonably free from any but small errors due to vertical currents.

The first ascent was made on September 5th. The lift given was 907 grams. The ascent began at 14h. 30m. and the balloon burst after a flight of 67 minutes. Visibility was excellent and the balloon was seen to be torn into several distinct and separate fragments. The mean rate of ascent of the balloon was 1,165 feet per minute over the first 10 minutes, and 1,125 feet per minute over the first 20 minutes. At the 66th minute the height was about 76,200 feet, which is now the record for this station. As far as is known winds have never before been measured at this height with two theodolites.

The wind structure on this day was such that the balloon throughout its flight was never more than 3 miles horizontally from the point of release. Indeed after the 27th minute the angle of elevation at both theodolites was always over  $80^\circ$  and on one occasion reached  $88.9^\circ$ . This, of course, gave excellent triangulation as far as horizontal motion was concerned, but rendered the internal agreement of the heights less exact than usual. The wind structure showed an easterly current up to 13,000 feet, a transitional stage up to 17,000 feet and then a westerly drift up to 57,000 feet. The balloon crossed the base line between the observing stations at a height of 36,000 feet. Between 57,000 feet and 76,000 feet the balloon described a complete spiral, and when last seen was travelling towards the south-east. In many places the wind was very light. Above 5,000 feet it never reached 30 feet per second, and above 36,000 feet it did not anywhere exceed 20 feet per second. There were several patches of very light airs.

The second balloon was released on September 15th. It was given a free lift of 794 grams and the ascent began at 9h. 35m. The balloon survived for 60 minutes and was then seen to collapse; it remained however in one piece. Over the first 10 minutes the mean rate of ascent was 1,105 feet per minute and over the first 20 minutes 1,095 feet per minute. At the 60th minute the balloon was at a height of about 65,000 feet. On this day there was a light wind at the surface from the south-west. At 7,000 feet this had veered to north-west, and this general direction was maintained all the way up to 65,000 feet. At 12,000 feet the wind strengthened to over 50 feet per second and maintained these speeds to about 50,000 feet when the wind fell off somewhat in velocity. The later part of this ascent is rendered somewhat uncertain by the small parallax of the base line, which fell to  $0.9^\circ$  at the 60th minute. Working was done as usual with graphically smoothed parallaxes.

On the following day, September 16th, a flight was made with the remaining balloon, commencing at 9h. 45m. On this occasion a free lift of 681 grams was applied. This balloon was observed for 79 minutes and was then perceived to collapse and fall, like the second balloon, in one piece. Over the first ten minutes the rate of ascent was 1,026 feet per minute, and over the first 20 minutes 1,010 feet per minute. At about the 70th minute the rate of ascent began to fall and the balloon only rose about 4,000 feet in the remaining 10 minutes of the flight. At the 79th minute the height was about 74,300 feet.

The wind structure on this day was as follows. The light south-easterly drift at the surface soon passed through south to south-south-west, and at 10,000 feet a current of 20 to 30 feet per second from a point between south and south-south-west was established, which persisted very regularly up to about 32,000

feet. This current then freshened very considerably and the direction kept much nearer south. At 47,000 feet the speed began to fall off rapidly and the direction worked into the south-west and west-south-west. The fall off in velocity continued, and the wind was down to light airs by 66,000 feet. These calm conditions remained till about 70,000 feet when the wind began to freshen again to about 20 feet per second, but now from the north. Unfortunately the lifting power of the balloon, which had been well maintained until now, began to fail rapidly and soon after the balloon burst. In the last 4,000 feet, however, the northerly current seems to have become well established.

Examining the data here obtained in connexion with the usual formula

$$V = g \frac{L^{\frac{1}{2}}}{(L + W)^{\frac{1}{2}}}$$

we derive the following values of  $g$

Balloon.	$W$	$L$	$V$	$g$
September 5th ...	735	907	1,165	456
„ 15th ...	735	794	1,105	452
„ 16th ...	735	681	1,025	441

It will be noticed that there is a decrease in the value of  $g$  with the free lift. There are insufficient data here to show whether the effect is real, but there seems to be no reason for regarding  $g$  as a constant even for a given balloon. The dimensions of the equation indicate a somewhat complex structure for  $g$ .

The following conclusions seem to emerge from the results of these balloon ascents:—

(1) The appropriate value of  $g$  for a 735-gram balloon is about 450 with the possibility that this quantity is also a function of the free lift.

(2) The balloons are capable of reaching a height of about 75,000 feet normally and probably as much as 80,000 feet might be secured on some occasions.

(3) There are varied and unexpected wind structures in the lower regions of the stratosphere.

The base lines used in normal pilot balloon work here are much too short for really satisfactory performance in long ascents of this type. The possibilities of a base line of about 22,000 feet are being examined with a view to its use if further ascents with these 735-gram balloons can be arranged.

C. BRITTON.

### Bibliography of Actinometry

The issue of the "Bibliography of Actinometry" initiated by M. Volochine\* is being actively carried forward. A series of

\* See *Meteorological Magazine*, 67, 1932, p. 238.

abstracts recently received deals mainly with papers published in the U.S.A. previous to 1930, but also includes abstracts of eight papers by British authors. Abstracts of most of the British contributors will be issued in a later series.

## Obituary

*Vice-Admiral Hugo Dominik.*—We much regret to record the death of Vice-Admiral Hugo Dominik, the President of the Deutsche Seewarte, which occurred at Hamburg on September 15th. Though his friends had known for some time that his health was failing the end came with tragic suddenness, for the same post which brought to the Meteorological Office the official announcement of his death also brought a letter on routine business bearing his autographed signature.

Admiral Dominik became President of the Seewarte in September, 1926. His earlier career had been spent in the German Navy. Though most of the commands he had held had been on the fighting side he was a man of wide scientific interests which he had found time and opportunity to foster. He had been in command of the Survey Ships "Planet" and "Möwe," and his work in them had brought him into frequent contact with the scientific institution which, in after years, he was to direct. The scientific traditions of the Seewarte were thus safe in his keeping.

Among meteorologists Dominik has won for himself a unique position during the few years of his directorship, for it is to him that we owe the suggestion to celebrate the jubilee of the First Polar Year by repeating the original enterprise in an extended form. Though some looked askance at the suggestion, when he first mooted it, as being impracticable in the difficult economic times through which the world was passing, yet the idea caught the imagination and eventually sufficient promises of co-operation were forthcoming to ensure success. During the thirteen months August, 1932, to August, 1933, many countries have sent special expeditions to make meteorological and geophysical observations in polar and sub-polar regions. It must have been a source of bitter disappointment to Dominik that the proposed official German co-operation had to be abandoned for financial reasons, and it is tragic to think that he himself has now passed away before even the first fruits of the enterprise have been gathered.

Though the proposed German expedition has proved impracticable, the Seewarte is nevertheless taking an active share in the work; a share which corresponds closely with that which our own Office took in the venture of 1882-3. For that year we prepared and published daily synoptic charts of the North

Atlantic Ocean and adjoining continents using in them all observations from ships and shore stations which we could come by. Things have changed in 50 years, and synoptic broadcasts now give us the material for constructing, day by day, maps of the North Atlantic which in 1882 took months or even years to compile. Nevertheless the need for authoritative maps embracing the greatest possible area remains one of which all meteorologists are conscious. The possibility of meeting the demand has been discussed at most recent international conferences, and a plan has at last been formulated for effective international co-operation, under which the Seewarte is acting as a central collecting house and undertakes the task of plotting the collected material. Specimen charts embracing the whole Northern Hemisphere were printed at the Seewarte and submitted by Admiral Dominik for the approval of the International Meteorological Committee at its meeting in Locarno in 1931. In due course we may expect to have the complete set for the 13 months comprising the Polar Year 1932-3, with at any rate some prospect that the enterprise may take permanent shape and be continued in subsequent years. Admiral Dominik's name is thus permanently linked up with two of the great co-operative meteorological efforts of our time.

By German meteorologists his loss will be felt in a peculiarly personal manner, for the jubilee meeting of the Deutsche Meteorologische Gesellschaft is being held at Hamburg as these notes go to press. For many who had looked forward to a personal meeting with the distinguished head of the Seewarte the occasion has been turned from one of rejoicing to one of mourning.

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*Mr. William George James.*—Mr. James, whose death on August 24th at the age of 82 was briefly recorded in our last issue, was born in 1851 and entered the Meteorological Office in June, 1864, being appointed to the Ocean Meteorology Branch. He rose to the rank of Staff Assistant and retired on December 31st, 1919, the whole of his long period of service being occupied in marine meteorology. He was especially associated with the preparation of the Monthly Meteorological Charts for the North Atlantic Ocean and East Indian Seas and other atlases of ocean meteorology, and he developed great skill and accuracy in the responsible cartographic work required for these charts.

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### News in Brief

We learn that Prof. Dr. Martins Costa has resigned from the directorship of the Instituto de Meteorologia Hidrometria e Ecologia Agricola at Rio de Janeiro and was succeeded by Mr. P. E. Magarinos Torres on June 1st, 1933.

## The Weather of September, 1933

Pressure was above normal over Spitsbergen, Iceland, northern, central and south-east Europe (including Italy and south-west Portugal and Spain), part of the North Atlantic, Bermuda and northern Labrador, the greatest excess being 10.3 mb. at Haparanda. Pressure was below normal over France, Switzerland and most of the Iberian Peninsula, most of the North Atlantic including the Azores, Canada (except northern Labrador) and the United States the greatest deficits being 6.2 mb. at 50° N. 100° W. and 2.7 mb. at Corunna. Temperature was above normal at Spitsbergen and northern and central Europe, but below normal in south-west Europe. The rainfall distribution was irregular in Sweden, being above normal only in southern Norrland, in Dalecarlia and Gothland.

Warm and unusually sunny weather prevailed over the British Isles during September with a general lack of rain in Scotland, Ireland and north and west England. Some new sunshine records were set up—at Ballinacurra, Co. Cork, 205.9hrs. of bright sunshine were registered during this September, the previous highest amount being 188hrs. in September, 1906. The drought ended in south England on the 12th, but in many places in the north and west it was not broken until the 17th, and at Felixkirk (Yorkshire) not until the 20th. During the first days of the month occasional slight rain or drizzle was experienced in the north and west, but on the 3rd the anticyclone over the south of the country spread northwards and warm dry sunny weather prevailed over the whole country. The warmest days were the 3rd and 4th when 80° F. and over was recorded at several places and 83° F. at Cambridge and Woodhall Spa (Lincolnshire). Sunshine records frequently exceeded 11hrs. each day, and 12.3hrs. was recorded at Lowestoft and 12.2hrs. at Littlehampton and Bath on the 5th and 12.2hrs. at Catterick on the 2nd. During the night of the 11th-12th a depression over the Bay of Biscay moved north-eastwards and rain fell heavily in southern England on the 12th, 2.09 in. at Ventnor, 1.81 in. at Southsea and 1.40 in. at Chewton Mendip, Somerset. Rain was also experienced generally in the south-east the following day and slight drizzle locally in the eastern districts, but in the west the dry anticyclonic conditions continued though with cool northerly winds. On the 14th-16th the anticyclone passed again across the country and sunny dry weather was renewed, warm during the day but cold at night, ground frosts being general on the 14th to 16th. Sunshine records exceeded 11hrs. locally and on the 14th reached 12.1hrs. at Calshot. On the 16th a secondary depression approached Ireland and slight rain fell in Ireland and south England that day. On the 17th rain fell and from then until the 26th a complex low-pressure area moved over the country and the weather was generally mild and unsettled but with long



periods of bright sunshine. Tiree had 11·2hrs. bright sunshine on the 24th. Thunderstorms, severe in places, occurred over a wide area during this period and in the south were often accompanied by heavy rain especially on the 24th and 26th.\* A southerly gale occurred at Lerwick on the 18th and a north-easterly gale at Inchkeith on the 24th. On the 26th the anticyclones over the North Atlantic and Scandinavia joined up across Scotland and Ireland and then extended over the rest of the British Isles. Weather was fair to cloudy with slight rain or drizzle locally whilst mist was experienced generally with fog at times in the Midlands and east England. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	156	+40	Liverpool	160	+38
Aberdeen	148	+24	Ross-on-Wye	163	+27
Dublin	154	+15	Falmouth	197	+34
Birr Castle	169	+43	Gorleston	179	+17
Valentia	205	+72	Kew	190	+45

The special message from Brazil states that the rainfall was scarce over the whole country with averages 0·55in. 0·16in. and 0·28in. below normal in the northern, central and southern regions respectively. Three anticyclones passed across the country. The crops were generally in good condition. At Rio de Janeiro pressure was 0·9 mb. above normal and temperature 0·7° F. below normal.

*Miscellaneous notes on weather abroad culled from various sources.* Storms were experienced generally in France between about the 8th and 13th, when five people were drowned and many vineyards were destroyed. It is reported that widespread damage has been caused by rain to the grain crops in the Urals, western Siberia and south Russia. Eight people were drowned at Montpellier about the 27th, when a house collapsed as the result of floods following heavy rain. Severe storms were also experienced in Provence. On the 30th, the river Loire rose nearly 8 ft. owing to violent rainstorms, and stormy weather occurred generally in south France. (*The Times*, September 14th-October 2nd.)

Although the rains of August eased the drought in Cape Province and the Orange Free State, it was reported on the 19th that there was still great need of rain in the north of South Africa. (*The Times*, September 20th.)

Floods continued throughout central and western India during the first half of the month. On the 20th it was reported that the Arabian Sea monsoon was weakening, and on the 27th that the monsoon had withdrawn from India. A typhoon struck the coast in the Shanghai region on the 3rd, and another typhoon

\* See p. 211 and p. 212.

struck Shanghai at midnight on the 18th, causing floods. (*The Times*, September 15th-29th.)

At the end of the month advices were received that good general rains had fallen over many areas of New South Wales, Queensland and Victoria. (*The Times*, September 29th and October 3rd.)

In Canada severe frosts in the Peace River District and moderate frosts in northern and central Alberta damaged late crops. The hurricane which struck the Bahamas on August 31st passed along the north-east coast of Cuba from Caibarien to Havana on the 1st, and then continued westward through the Gulf of Mexico, striking Texas near Freeport on the 4th, and passing through a large part of southern Texas on the 5th. About 150 people were killed in Cuba and 1,000 injured; coast towns and sugar districts suffered most. The hurricane reached its maximum intensity at Havana at 5 p.m. on the 1st, when the wind velocity was 98 m.p.h. In Texas 32 people were killed mainly owing to the huge waves which flooded communities on the coast and thousands were rendered homeless—the material damage here was estimated at \$12,000,000, the greatest damage being to the citrus crops. Another hurricane blowing with a velocity of 100 m.p.h. swept the Bahamas on the 3rd and continued in a north-westerly direction, striking the east coast of Florida on the 4th. In Florida two lives were lost, and it is estimated that 70 per cent of Florida's citrus crop was ruined. Two tropical storms struck the east coast of Mexico on the 4th, doing damage to water-front buildings. A hurricane swept along the Atlantic seaboard of North Carolina and Virginia on the 16th, many of the coastal towns were flooded and 15 people were killed. In a hurricane which occurred shortly before the 20th in Mexico 135 people lost their lives and 3,000 were made homeless in consequence of the ensuing floods. A hurricane raged near Tampico, Mexico, for nearly 12 hours on the 24th, and then passed inland as far as Victoria and S. Luis Potosi; floods occurred generally owing to the overflowing of the Panuco and Tumbesi Rivers and huge waves from the Gulf, so that more than 54 people were killed. Temperature was above normal over the whole of the United States, except the Pacific Coast, while the rainfall distribution was irregular. Good general rains fell over the whole Argentine agricultural zone. (*The Times*, September 2nd-28th, and *Washington, D.C., U.S. Dept. Agric. Weekly Weather and Crop Bulletin*.)

### General Rainfall for September, 1933

England and Wales	...	94	} per cent of the average 1881-1915.
Scotland	...	41	
Ireland	...	45	
British Isles	...	<u>70</u>	

## Rainfall: September, 1933: England and Wales.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>London</i>	Onsmiden Square .....	3'01	105	<i>Leis.</i>	Thornton Reservoir ...	1'40	77
<i>Kent</i>	Tonterton, Ashenden...	4'32	202	"	Belvoir Castle.....	2'04	109
"	Folkestone, Boro. San.	5'79	...	<i>Kut</i>	Ridlington .....	2'09	109
"	St. Peter's, Hildersham	...	...	<i>Linca</i>	Boston, Skirbeck .....	1'99	118
"	Eden'bdg., Falconhurst	3'52	155	"	Oranwell Aerodrome ...	2'07	110
"	Sevenoaks, Speldhurst	3'20	...	"	Skogness, Marine Gdns	1'11	61
<i>Sus</i>	Compton, Compton Ho.	2'88	108	"	Louth, Westgate .....	1'65	82
"	Patching Farm .....	4'17	174	"	Brigg, Wrawby St. ...	1'79	...
"	Eastbourne, Wil. Sq.	4'62	185	<i>Notts</i>	Workop, Hodsock ...	1'48	94
"	Heathfield, Barklye ...	4'24	173	<i>Derby</i>	Derby, L. M. & S. Rly.	1'80	115
<i>Hants</i>	Ventnor, Roy. Nat. Hos.	4'45	179	"	Buxton, Terr. Slopes	'81	25
"	Fordingbridge, Oaklands	2'65	123	<i>Ches</i>	Runcorn, Weston Pt. ...	'60	22
"	Ovington Rectory .....	3'80	166	<i>Lancs.</i>	Manchester, Whit Pk.	1'08	46
"	Shorborne St. John .....	4'13	201	"	Stonyhurst College ...	1'00	26
<i>Herts</i>	Welwyn Garden City...	2'48	...	"	Southport, Heslith Pk	'77	28
<i>Bucks</i>	Slough, Upton .....	2'45	139	"	Lancaster, Greg Obsy.	1'05	31
"	H. Wycombe, Blackwell	2'37	...	<i>Yorks.</i>	Wath-upon-Deane ...	1'70	118
<i>Oxf</i>	Oxford, Mag. College...	1'97	117	"	Wakefield, Clarence Pk.	1'00	100
<i>Nor</i>	Pitsford, Sedgemoor...	1'67	87	"	Oughtershaw Hall.....	2'78	...
"	Oundle.....	2'51	...	"	Wetherby, Ribston H.	2'11	117
<i>Beds</i>	Woburn, Crawley Mill	1'84	103	"	Hull, Pearson Park ...	2'81	163
<i>Cam</i>	Cambridge, Bot. Gdns.	1'74	108	"	Holme-on-Spalding ...	1'93	...
<i>Essex</i>	Chelmsford, County Lab.	1'80	110	"	West Witton, Ivy Ho.	2'04	95
"	Lexden Hill House ...	1'70	...	"	Kelkirk, Mt. St. John	1'50	82
<i>Suff</i>	Hangley House.....	2'52	...	"	York, Museum Gdns.	2'00	128
"	Campsea Ashe.....	3'44	180	"	Pickering, Hungate ...	1'70	89
"	Lowestoft Soc. School	3'33	170	"	Scarborough .....	1'42	79
"	Bury St. Ed., Westley H.	2'88	145	"	Middlesbrough .....	1'32	80
<i>Norfolk</i>	Wells, Holkham Hall	1'07	88	"	Baldorsdale, Hury Ros.	1'00	76
<i>Wilts</i>	Davizes, Highclere.....	2'85	140	<i>Durh.</i>	Ushaw College .....	2'09	149
"	Calne, Onslowway .....	4'14	201	<i>Nor</i>	Newcastle, Town Moor	1'69	83
<i>Dor</i>	Evershot, Melbury Ho.	2'75	108	"	Bellingham, Highgreen	1'46	61
"	Weymouth, Westham ...	2'18	104	"	Lilburn Tower Gdns...	1'48	63
"	Shaftesbury, Abbey Ho.	2'42	99	<i>Cumb.</i>	Carlisle, Scaleby Hall	'68	25
<i>Devon</i>	Plymouth, The Hoe ...	1'76	89	"	Borrowdale, Seathwaite	2'00	21
"	Holne, Church Pk. Cott.	3'82	101	"	Borrowdale, Moraine...	1'79	...
"	Teignmouth, Den Gdns.	2'83	142	"	Keawick, High Hill...	'98	28
"	Oullompton.....	1'44	84	<i>Wesl</i>	Applaby, Castle Bank	1'51	59
"	Sidmouth, Sidmount...	1'02	83	<i>Mon</i>	Abergavenny, Larch...	2'40	103
"	Barnstaple, N. Dev. Ath.	1'82	49	<i>Glam.</i>	Ystalyfera, Worn Ho.	2'40	56
"	Dartm'r, Cranmere Pool	2'20	...	"	Cardiff, Ely P. Stn. ...	1'90	61
"	Okhampton, Uplands	2'82	87	"	Treharbert, Tynywaun	2'89	...
<i>Corn</i>	Radruith, Trewirgie ...	1'80	83	<i>Carm.</i>	Carmarthen Friary ...	1'99	58
"	Ponzaunce, Morra Gdn.	2'79	95	<i>Pemb.</i>	Haverfordwest, School	2'02	74
"	St. Austell, Trevarna...	2'67	84	<i>Card</i>	Aberystwyth .....	1'17	...
<i>Som</i>	Oxewton Mendip .....	2'80	94	<i>Rad</i>	Birm W.W. Tyrnynydd	1'22	81
"	Long Ashton .....	2'85	98	<i>Mont</i>	Lake Vyrnwy.....	1'88	88
"	Street, Millfield.....	1'64	73	<i>Wint</i>	Sealand Aerodrome ...	'49	24
<i>Glos</i>	Blockley .....	2'01	...	<i>Mer</i>	Dolgelly, Bontddu ...	1'77	42
"	Gloucester, Gwynfa ...	3'04	138	<i>Carn</i>	Llandudno .....	1'18	50
<i>Here</i>	Ross, Birchlea.....	3'03	158	"	Snowdon, L. Llydaw ...	3'68	...
<i>Salop</i>	Church Stretton.....	1'37	67	<i>Ang</i>	Holyhead, Salt Island	'94	85
"	Shifnal, Hatton Grange	'85	34	"	Llglwy.....	1'16	...
<i>Staffs</i>	Market Drayton, Old Sp.	'78	88	<i>Ile of Man</i>			
<i>Worc</i>	Ombersley, Holt Look	1'08	61	"	Douglas, Boro' Cem. ...	'98	80
<i>War</i>	Alcester, Ragley Hall..	1'87	77	<i>Guernsey</i>			
"	Birmingham, Edgbaston	'71	40	"	St. Peter P't. Grange Rd	8'68	140

## Rainfall: September, 1933: Scotland and Ireland.

Co.	STATION	In.	Per- cent of Av.	Co.	STATION	In.	Per- cent of Av.
Wig.	Pt. William, Monroith	.02	21	South	Melville	.60	21
	New Luce School	.60	14		Loch Mòr, Achfary	1.55	27
Kirk	Dalry, Glendarroch	.89	24	Caith.	Wick	1.17	47
	Cairnphalm, Shiel	1.83	34	Ork.	Doorness	1.19	41
Dumf.	Dumfries, Crichton, R.I.	1.16	46	Shet.	Lerwick	2.17	72
	Eskeleminair Obs.	1.04	28	Cork	Cahernagh Rectory	1.21	...
Roeb.	Branchholm	1.11	50		Dunmanway Rectory	1.54	88
Salk.	Eltrick Manso	1.47	41		Cork, University Coll.	1.59	50
Peab.	West Linton	1.07	...		Ballinacra	1.04	41
Herw.	Marchmont House	1.34	50	Kerry	Valentia Obsy	2.47	60
E. Lot.	North Berwick Res.	1.21	58		Gearhamoon	1.80	20
Midl.	Edinburgh, Roy. Obs.	1.87	91		Darvynane Abbey	2.05	58
Lan.	Auchtyfardle	...	...	Wat.	Waterford, Gortmore	2.24	82
Ayr	Kilmarnock, Kay Pk.	.76	...	Tip.	Nonagh, Cas. Lough	1.67	59
	Girvan, Plunmore	.74	19		Roseroa, Timoney Park	2.36	...
Renf.	Glasgow, Queen's Pk.	.81	29		Cashel, Ballinamona	2.21	90
	Greenock, Prospect H.	.71	16	Lim.	Foynes, Coolnances	.83	80
Bute	Rothsay, Ardeneraig	1.19	...		Castleconnel Roc.	1.53	...
	Dougarie Lodge	1.49	...	Clare	Inagh, Mount Callan	1.50	...
Arg.	Ardgour House	1.80	...		Broadford, Hurdle's n.	1.57	...
	Glen Etive	...	...	Wexf.	Gorey, Courtown Ho.	1.37	55
	Oban	1.07	24	Kilk.	Kilkenney Castle	1.92	88
	Poltalloch	2.12	46	Wick.	Rathnew, Clonmannon	1.93	...
	Inveraray Castle	1.38	21	Carl.	Hacketstown Rectory	1.80	64
	Islay, Ballabus	1.08	26	Leix.	Blandsfort House	2.10	77
	Mull, Benmore	3.03	...		Mountmellick	2.25	...
	Tiree	1.87	37	Offaly.	Birr Castle	1.40	61
Kinr.	Loch Leven Sluice	2.20	80	Dublin	Dublin, FitzWm. Sq.	.07	51
Perth	Loch Dhu	1.70	30		Balbriggan, Ardgillan	1.22	00
	Balquhlder, Stronvar	1.33	...	Meath.	Beauparc, St. Cloud	.80	...
	Crieff, Strathearn Hyd.	1.72	00		Kells, Houdfort	.61	28
	Blair Castle Gardens	1.89	80	W. M.	Moate, Coolatora	1.20	...
Angus.	Kettles School	2.11	95		Mullingar, Belvedere	.82	30
	Pearls House	2.13	...	Long.	Castle Forbes Gdns.	.81	28
	Montrose, Sunnyside	1.13	57	Gal.	Galway, Grammar Sch.	1.31	...
Abor.	Braemar, Bank	2.20	91		Ballynahinch Castle	2.52	53
	Logie Coldstone Sch.	1.78	...		Alasragh, Glenbrook	1.48	48
	Aberdeen, King's Coll.	.00	41	Mayo.	Blacksod Point	...	...
	Fyvie Castle	1.87	52		Mallaranny	2.52	...
Moray	Gordon Castle	2.04	82		Westport House	1.06	40
	Grantown-on-Spey	.99	40		Dolphin Lodge	3.18	37
Nairn.	Nairn	.74	84	Sligo.	Markree Obsy	.85	25
Inv's	Bon Alder Lodge	...	...	Ferm.	Enniskillen, Portora	.34	...
	Kingussie, The Birches	1.34	...	Arm.	Armagh Obsy	.15	0
	Inverness, Oulduthel R.	1.02	...	Down.	Fofanny Reservoir	1.76	...
	Loch Quoich, Loan	...	...		Seaford	.78	27
	Glenquoich	1.07	19		Donaghadee, O. Stn.	.70	32
	Arisaig, Fairs-na-Sguir	1.32	...		Banbridge, Milltown	1.59	05
	Fort William, Glasdrum	...	...	Antr.	Belfast, Caveshill Rd.	.01	...
	Skye, Dunvegan	1.12	...		Aldergrove Aerodrome	.52	21
	Barra, Skallary	1.43	...		Ballinacra, Harryville	.61	20
R & O.	Alness, Ardross Castle	.53	18	Lon.	Garvagh, Moneydig	1.12	...
	Ullapool	.50	13		Londonderry, Oreggan	.86	26
	Achnashellach	1.07	15	Tyr.	Omagh, Edenfel	.46	16
	Stornoway	.00	28	Don.	Malin Head	.54	...
South	Lairg	.14	5		Milford, The Mause	.73	22
	Tongue	.02	29		Killybegs, Rookmount	.47	...

## Climatological Table for the British Empire, April, 1933

STATIONS	PRESSURE		TEMPERATURE						PRECIPITATION		BRIGHT SUNSHINE					
	Mean of Day M.S.L.	Diff. from Normal	Absolute		Mean Values				Mean Cloud Amt	Rela- tive Hu- midity	Amt	Diff. from Normal	Days	Hours per day	Per- cent- ages of possible	
			Max.	Min.	Max.	Min.	1/2 max. and min.	Diff. from Normal								Wet Bulb
London, Kew Obsy.	1020.0	+ 5.6	80	32	57.6	41.0	49.3	+ 2.0	6.1	0.66	0.79	6	5.8	42		
Gibraltar	1017.4	+ 1.0	72	48	72.1	53.5	62.8	+ 1.9	4.6	2.86	0.17	5	..	..		
Malta	1016.9	+ 3.5	74	48	65.2	54.6	59.9	- 1.0	5.4	0.06	0.80	3	9.3	71		
St. Helena	1012.4	- 0.2	72	58	67.9	61.4	64.7	- 0.6	8.7	1.40	..	17	..	..		
Freetown, Sierra Leone	1011.5	+ 0.7	93	71	90.3	76.9	88.1	+ 0.7	6.3	3.72	0.34	11	..	..		
Lagos, Nigeria	1009.7	+ 0.3	95	72	89.1	76.8	82.9	+ 0.1	7.8	..	0.84	9	..	..		
Kaduna, Nigeria	1009.5	- 2.2	100	65	93.8	72.3	83.1	+ 1.6	6.3	3.95	2.18	8	6.6	54		
Zomba, Nyasaland	1014.6	+ 2.1	88	55	78.6	61.5	70.1	+ 0.8	6.0	3.04	0.04	8	7.8	68		
Salisbury, Rhodesia	1015.0	- 0.3	89	44	77.5	53.1	65.3	0.4	6.4	0.46	3.20	6	..	..		
Cape Town	1017.0	+ 0.6	104	44	76.7	56.7	66.7	+ 3.5	2.7	2.57	1.58	7	8.7	74		
Johannesburg	1016.9	+ 0.7	81	38	70.8	50.1	60.5	+ 0.5	3.6	0.64	1.23	3	..	..		
Mauritius	1018.2	- 0.8	84	66	82.0	71.8	76.9	+ 1.1	2.3	3.38	1.64	7	9.3	81		
Calcutta, Alipore Obsy.	1007.2	+ 0.9	101	68	95.0	75.5	85.3	- 0.3	6.4	2.60	1.87	22	6.6	57		
Bombay	1009.0	+ 0.2	94	73	90.5	77.8	84.1	+ 1.0	8.1	3.16	0.98	6*	..	..		
Madras	1009.0	+ 0.6	98	71	91.3	77.5	84.4	- 0.9	7.2	0.00	0.05	0*	..	..		
Colombo, Ceylon	1009.9	+ 1.2	91	73	88.0	76.0	82.0	0.7	6.0	0.03	0.60	0*	..	..		
Singapore	1009.2	+ 0.3	92	70	87.9	74.3	81.1	- 0.5	6.7	8.25	0.48	18	8.5	69		
Hongkong	1012.9	+ 0.3	87	57	77.3	68.3	72.8	+ 2.0	6.9	4.33	3.30	17	6.6	46		
Sandakan	1010.0	..	89	74	87.5	76.0	81.7	- 0.5	7.8	1.91	3.74	8	4.8	38		
Sydney, N.S.W.	1019.4	+ 1.0	89	46	71.1	56.3	63.7	- 0.5	6.0	4.35	0.14	9	..	..		
Melbourne	1020.8	+ 1.3	86	37	69.0	49.9	59.5	0.0	5.7	7.54	2.02	14	5.7	53		
Adelaide	1021.3	+ 1.4	85	45	72.6	52.6	62.6	- 1.3	6.0	0.55	1.62	7	6.0	54		
Perth, W. Australia	1018.4	+ 0.0	90	48	78.6	58.1	68.3	+ 1.5	3.1	1.98	0.25	7	7.1	64		
Coalgardie	1018.8	+ 0.2	93	43	78.3	50.5	64.4	- 0.6	5.9	0.80	0.35	5	8.5	75		
Brisbane	1018.2	+ 0.6	90	56	78.3	61.8	70.1	0.2	4.3	0.30	0.86	2	..	..		
Hobart, Tasmania	1017.4	+ 2.6	70	36	59.3	46.1	52.7	- 2.5	6.4	8.95	5.13	9	7.7	67		
Wellington, N.Z.	1011.4	- 6.7	70	41	62.2	50.9	56.5	- 0.6	6.4	2.22	0.37	12	5.4	50		
Suva, Fiji	1010.7	+ 0.1	92	71	83.9	73.9	78.9	+ 0.3	5.7	4.07	0.19	11	6.1	55		
Apis, Samoa	1010.2	+ 0.3	88	72	86.3	74.5	80.4	+ 1.5	7.8	33.09	20.88	27	3.2	27		
Kingston, Jamaica	1012.7	- 1.4	92	68	86.9	70.7	78.8	- 0.4	8.2	17.04	6.59	22	5.8	49		
Grenada, W.I.	1014.0	- 2.1	71	27	52.6	37.4	45.0	+ 2.9	1.9	0.05	1.19	2	10.7	86		
Toronto	1015.7	- 1.0	72	14	45.3	28.6	36.9	- 0.8	5.6	2.47	0.18	16	5.4	40		
Winnipeg	1016.3	+ 2.9	57	22	46.3	32.6	39.5	+ 0.5	6.4	0.20	1.20	2	7.1	52		
St. John, N.B.	1018.9	+ 1.4	63	36	54.0	41.2	47.6	- 0.3	7.0	5.07	1.56	16	4.5	33		
Victoria, B.C.	1018.9	+ 1.4	63	36	54.0	41.2	47.6	- 0.3	5.8	0.34	1.18	5	8.5	63		

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## Meteorology at the Meeting of the British Association for the Advancement of Science, Leicester, 1933

The subject of meteorology played an important part in the programme of the recent meeting of the British Association for the Advancement of Science, for not only was there the usual session of the Department of Cosmical Physics of Section A (Mathematical and Physical Sciences) devoted to meteorology and geophysics, but the President of Section A itself was this year a meteorologist, Sir Gilbert Walker, C.S.I., F.R.S., and three foreign geophysicists, Prof. Franz Linke, Prof. E. Regener, and Prof. L. Vegard, attended the meeting and contributed to the discussions. In addition there were, as usual, a few papers concerning meteorology and climatology read in other Sections of the Association.

A wide variety of subjects was discussed, and some general advance of knowledge could be discerned, even if there was little indication of the generation of a "new line of thought," the absence of which is so much regretted by the Editor of the *Quarterly Journal of the Royal Meteorological Society* in a recent number of that journal.

Sir Gilbert Walker's presidential address was on seasonal weather and its prediction, a subject of great interest to the professional meteorologist, the industrialist whose activities are affected by the weather, and the "man-in-the-street." Much

has been written on the subject and most of what has been written can be criticised, sometimes for the admixture of too much imagination with too few data, and sometimes for the absence of common sense from purely numerical arguments. Sir Gilbert struck an agreeable compromise, by cheerfully admitting the limitations of the evidence so far available, while showing that the phenomena are real and important and demand explanation. In this magazine it is perhaps unnecessary to describe in detail the nature of the relations between the abnormalities of seasonal pressure, rain, etc., in one part of the world and another, which was the main subject of the address; for much of this has appeared in the past in the technical press and the address will appear in full elsewhere. Rather, it may be of greater interest to consider how some of the salient conclusions were likely to be received by a member of the audience who had come for the first time from other fields of physics to the contemplation of this branch of meteorology. No apology is offered for doing this, for it is admittedly difficult for one engaged continuously in the study of one subject always to discern the wood from the trees, and it is possible we may gain from considering the outsider's point of view.

A physicist in the habit of measuring constants and effects to the *n*th place of decimals might be tempted to scoff at a science which deals with reactions which can only be relied on to "come off," say, 70 per cent. of the times they are tried. As has been indicated, this criticism was met by Sir Gilbert by a clear defence of the reality of correlation ratios—"statistical methods show us what quantities vary together, but strictly by themselves they tell us nothing as to causation." He might have gone on to say that it has been argued that even the simplest and most direct "causes" and "effects" of the physical world are merely events which happen to follow each other so very frequently that we have come to regard their sequence as inevitable. This perhaps is quibbling, and there is a moral to be learnt from the attitude of our hypothetical physicist—that qualitative theories which appear usually to be valid are not good enough, and greater and greater exactness must be sought. Meteorological phenomena are so complicated that some can generally be found to support almost any theory. Sir Gilbert remarked that "more than once I have seen in journals of repute the artless remark of an author that if he were to limit his results to those which would satisfy the criteria of reality he would obtain few results of interest!"

It is disconcerting to the meteorologist, and perhaps amusing to our physicist, to find that a prediction formula will yield very good results for a large number of years, at any rate as regards extreme abnormalities of an element, and then without warning suddenly go wrong. It is understandable that the meteorologist

should be reluctant to publish forecasts while this sort of thing can happen, and of course he must not rest content (and is not doing so) to leave things in such a state. While, as Sir Gilbert says, "the forecasting efforts of a charlatan are judged by their occasional successes, and it is the occasional failures of a government department which are remembered against it," it is also perhaps wise that forecasts about which there is some doubt should not be published. But the correlation ratios quoted by Sir Gilbert, which are only a sample of what have been computed, really do show that forecasts can be made with much greater accuracy than can be done by tossing a coin.

Prof. Franz Linko took as his subject "The Influence of the Stratosphere on the Development of Cyclones," and introduced a discussion on the possibility of reconciling the Norwegian and German-Austrian schools of thought with the remark, "One notices that a temperamental contest has been taking place between Norwegians on one side and Germans and Austrians on the other side; one might say that there is a Norwegian-German front. This scientific front has led to a development of latent energy, and thereby advanced the science of meteorology." Since the first enunciation of the simple Norwegian frontal theory of cyclones, which concerned the troposphere alone, our picture of the origin of nature of cyclones has tended to become more and more complicated, as indeed it must become if it is to bear semblance to reality. Much has been written on the effect of tropopause waves on the pressure and weather conditions in the troposphere, and Prof. Linko visualised a complex series of possible actions and reactions between stratosphere and troposphere which would explain the known phenomena of the formation, movement and energy exchanges of cyclones. He concluded: "On account of the progress attained on both sides, the German-Norwegian front is about to die. The conflict as to whether the stratospherical or tropospherical occurrences are primary is based on a false question. In every level disturbances can originate whose effects extend throughout the air masses. . . . The theory of the complex cyclone is naturally a disillusion for all those meteorologists who had hoped to be able to calculate the variations of the weather by simple formulae. That will be possible only when every single day we have reports from a great area of the Earth's surface up to great heights. Remembering the great advances in the technique of flying, we can hope that that soon will be the case."

At one of the most entertaining and instructive meetings of Section A, Prof. Linko showed a ciné film of cumulus cloud formation. Photographs of clouds were taken at intervals of from 3 to 6 seconds throughout their life, and were put through the projector at the rate of 16 per second. The events of a whole afternoon were thus condensed down into a few minutes.



It was indeed fascinating to see a cloud begin to form over a ridge of hills, to watch it grow, the whole mass "boiling" furiously, and perhaps to see a big lump detach itself and float off as an isolated "wool pack," or to see an anvil form at the top. In another part of the film, typical heat convection, "April weather," clouds were seen to form and float away with the wind. One could have wished that the film was not speeded up so much, for, although the film was repeated, some of the more interesting phases in the life-history were over before one could see clearly what was happening. This simple, but extremely convenient and dramatic method of cloud study was devised in the course of investigating the meteorological conditions necessary for successful "gliding" and "soaring" flights, and it is proposed to go on and study other cloud types in the same way. The tedium involved in watching clouds for long periods of time is no doubt partly responsible for the sparseness of experimental verification of the suggestions which have been made regarding the mode of generation and change of form of clouds; and the rapid fire of questions which followed Prof. Linke's film demonstration showed how keenly field observations are appreciated.

It may perhaps be possible to obtain further evidence by the film method for the existence in the atmosphere of the various cloud forms so ingeniously obtained in the laboratory by Sir Gilbert Walker. One of his collaborators, Mr. A. Graham, gave an account of cloud forms produced in a thermally unstable layer of air, subjected to a single mechanical shear, and subjected to no shear. The forms obtained have all been observed in the atmosphere; but if the change from one form to another when the conditions change, and the direction of motion in the centres of the cells, could be clearly demonstrated by a ciné film, it would go far towards convincing one that the patterns observed in the sky are due to thermal instability and not to Helmholtz waves.

Prof. Vegard summarized existing knowledge of auroræ, and proceeded to discuss what can be deduced from it regarding the constitution of the upper atmosphere. The spectra of auroræ have been measured at Tromsø and elsewhere from 9,000 Å., right through the visible wave-lengths, to the limit of atmospheric transmission in the ultra-violet. Apart from the green line and two red lines, the spectrum is predominantly that of nitrogen, and there is no evidence for the layers of hydrogen and helium which it has been argued must exist in the upper atmosphere. An effect has been observed in which the nitrogen bands become enhanced relative to the green line, as the altitude increases; and the temperature of the molecules emitting the auroral light has been estimated from the negative nitrogen bands. This information, together with other observations

regarding the streamers, etc., has been utilised by Prof. Vegard to build up a fairly complete picture of the constitution of the upper atmosphere. He regards it as being similar to the sun's corona, and claims that his picture fits in with radio-echo work and with Rayleigh's and Slipher's spectral observations of the zodiacal light and the luminescence of the night sky. In the time allotted to this paper it was impossible that the subject should be considered in all its detail, and confirmation of the conclusions, either experimentally using the Polar Year data, or theoretically, will be awaited with interest.

If we may be permitted to make a distinction between geophysicists and other physicists, it may be claimed that in the early days cosmic radiation was primarily the study of geophysicists, and only later has it attracted wider attention. Would that physicists could be induced to take an interest in other meteorological studies, for although few can be expected to interest "electron chasers" in the way that cosmic radiation has, there are many with both theoretical and practical aspects which should stimulate the interest of physicists in general.

Prof. P. M. S. Blackett, F.R.S., opening a discussion on the positive electron, described how this was first detected by Anderson and by Blackett and Occhialini in the course of the study of cosmic rays by the cloud method. The photographs showed the presence of positively electrified particles, the mass and magnitude of the charge of which did not differ from those of the negative electron by more than 50 per cent. These positive electrons appeared to originate in some disruptive process brought about by incident cosmic radiation. In an earlier paper Prof. E. Regener had described his latest researches in the distribution of cosmic radiation. It was fascinating to hear at first hand from the inventor about the ingenious devices incorporated in his counting apparatus. The height is measured by the pressure, which is recorded by two aneroids, one of which is of very high sensitivity and only comes into play when the instrument is so high up that the one of ordinary sensitivity is recording only very inaccurately. Perhaps the neatest feature of the apparatus was the cellophane covering, which maintained the temperature up to or above the ground value at 30 Km. height. The action of the covering was the same as that which is supposed, but, according to Wood, does not, occur in a greenhouse.

The condensation of water plays such an important part in so many atmospheric phenomena that it is remarkable that we are still in comparative ignorance as to its mechanism. Some aspects of the problem were discussed at a meeting of the Department of Cosmical Physics, under the chairmanship of Prof. J. J. Nolan. It was evident from a number of the papers that experimental difficulties in the way of the investigation of this

subject are largely responsible for our ignorance. For example, Dr. G. C. Simpson believes that the appearance of maxima and minima in the frequency curves of cloud particle and rain-drop sizes found by several investigators is not due to the existence of groups of drop sizes in a regular series; but is due to some experimental error connected, perhaps, with the method of measurement of the drops.

Experimental difficulties were also referred to by Mr. H. L. Green, in a discussion of the methods that have been invented for measuring the number and sizes of particles in the atmosphere. He stressed the limited applicability of most of the methods, and remarked: "In a recent comprehensive account of methods for estimating dusts in industry, Professor Heymann, of the University of Berlin, refers to some seventy papers containing descriptions of sampling instruments. Unfortunately, although there is a wealth of instruments which are portable and easy to manipulate, it is difficult to find any that is really efficient in precipitating the particles of the aerosol in a state for effective examination. Workers have hitherto been handicapped by the absence of means for testing the efficiencies of their instruments, but with the advent of the ultra-microscope and sedimentation methods, this difficulty should disappear." Finally, Mr. L. H. G. Dines reported that "it is found that in about half of all the soundings (of the upper atmosphere, using meteorographs fitted with hair hygrometers) at some stage of the flight, the hair expands to a length greater than that corresponding with immersion in water or an ordinary artificial fog. . . . At first when this phenomena was noticed the writer supposed it to have little significance, and thought that probably it only represented the measure of his ignorance of the precise response of hairs to changing conditions of relative humidity. As time went on this explanation grew less tenable, and the conviction grew that there must be some physical condition present in many clouds which was not present in the ordinary artificial fog." The true interpretation of the hair hygrometer record when it shows an apparent super-saturation is still, however, a matter of speculation.

Prof. Nolan described some experiments made to test, amongst other things, whether the low mobility ions required by Wilson's theory of thunderstorm electrification are directly produced by discharge from rain-drops when subjected to the intense electric fields which obtain in thunder clouds. He found that no such ions are formed in clean air, even if the field is so intense that the drop is broken up, and that therefore some other explanation must be sought.

Mr. A. C. Best reported a series of two years' measurements of the temperature differences over the height intervals of 2.5 to 30 cm. and 30 cm. to 120 cm. over grass. Such measure-

ments as these are of first-class importance, for not only is the number available small, but also they are fundamental in all work dealing with stability and turbulence in the atmosphere. The main conclusions of the work were summarised by Mr. Best in a series of graphs and tables; but it is to be hoped that he will make the complete results available to the meteorological public in due course.

Climatology was this year left to the consideration of Section E—Geography. Prof. L. Rodwell Jones and Mr. F. H. W. Green dealt with the wind and rainfall of Kenya and Uganda. Naturally there are few data for some parts of these countries, but even so the effect of the major topographical features can be discerned. For instance, the eastern highlands form a definite rain "shadow"; and the northern rift separates one type of distribution from another in the same latitude. As regards wind, land and sea breezes are very prominent on the northern verge of Lake Victoria, and may at times deflect the normal monsoon directions at Zanzibar. In this section also there was a paper by Prof. C. Daryll Forde on "Variations in the native economy of arid regions," wherein he showed that climatic divisions into "hot" and "continental" deserts and gradations from winter to summer precipitation appear to be largely irrelevant to the classification of native economies, physiographic and biological conditions and cultural history being far more important.

Seismology was represented by two papers in the Department of Cosmical Physics (Section A†) meeting on September 12th. In the first, Mr. T. Tillotson argued that a wrong identification of one of the series of seismic waves arriving at an observatory has in some cases led to an incorrect conclusion as to the depth of focus of the earthquake. English earthquakes, although generally mild in intensity, are naturally of peculiar interest to an English audience, and the Association welcomed an account from Father J. P. Rowland, S.J., of his attempts to trace the source of an earthquake which disturbed the northern part of England on January 14th of this year. From the reports received from various parts of the country as to the intensity of the shock felt, it was possible to draw iso-seismal curves which centred roughly on north-west Yorkshire. More accurately timed data from a number of seismological observatories limited the area in which the focus probably lay to a small triangle near Hawes, wherein a fault is shown in the geological survey map. The data are not accurate enough to prove conclusively that the earthquake was associated with this fault, and not one of a number of others which lie fairly near, but Father Rowland considered there was little doubt that the source was somewhere in Wensley Dale.

M. G. BENNETT.

### The Amateur Meteorologist

Prof. J. Fairgrieve delivered an address before the Conference of Corresponding Scientific Societies entitled "The Amateur Meteorologist," in which he pointed out a number of ways in which amateurs could assist the science of meteorology. First came observations, especially of rainfall, wind and sunshine, by the establishment of instruments in places from which the information was at present insufficient. Another interesting subject for the amateur is the checking of weather forecasts as applied to his own locality, and there is also phenology, in which help will be warmly welcomed by the Royal Meteorological Society. From these individual examples he went on to what he considered the main characteristic of amateur work, namely, dealing with problems of large numbers of amateur and sometimes intermittent observations, while the province of the professional is more to deal exhaustively with a few accurate and continuous records. Thus an amateur can collect reports from the public and study the development and passage of a heavy thunderstorm or a fog, and the lecturer illustrated this aspect by reference to some amateur studies which he had himself carried out. Work of this kind is of value in encouraging the habit of observation in the public. Finally, he referred to the series of articles on "Problems of Meteorology" in the *Quarterly Journal*, and suggested that the amateur could tackle these physical and mathematical problems equally with the professional. Altogether, there is a great deal of scope for the amateur meteorologist.

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### Sunspots and Sunshine

The dates 1899, 1911 and 1921 given by Mr. J. B. C. Kershaw on p. 207 of the October issue of this magazine for the last three minima of the sunspot cycle are at variance with those officially accepted, which are 1901, 1913 and 1923. It is hardly probable, moreover, that 1933 will, as Mr. Kershaw anticipates, prove to be the year of the next minimum; during the past ten months there has at times been very considerable solar activity, in particular from January to March, when the spot-groups were on several occasions large enough to be seen through mist without telescopic aid.

Mr. Kershaw's contention that years of sunspot minimum are years of abundant sunshine in England must thus be regarded as negated by his own diagrams, which indicate that 1913 was markedly deficient in this respect, and that 1923 was sub-normal at a majority of the stations chosen for his investigation. (The Annual Summary of the *Monthly Weather Report* stigmatised 1923 as "a dull and wet year.") Furthermore, 1889, the last

spot-minimum year of the nineteenth century, has never since been equalled for sunlessness at Kew Observatory.

We have good evidence, however, that south-east England has, for some time past, experienced a bright and notably warm summer late in the declining phase of each sunspot cycle—usually about two years in advance of the minimum. The meteorological statistics at Greenwich Observatory show this to have occurred regularly back to 1876, when registration of sunshine was begun there. Since then the years of sunspot minimum have been\* 1878, 1889, 1901, 1913 and 1923. That the summers of 1876, 1887, 1899, 1911 and 1921 in this part of the country were all characterised by high temperature, and five of them, at least, by pronounced excess of sunshine, is demonstrated by the following abstracts from the Royal Observatory records. (Corresponding figures for 1933 are added for purposes of comparison.)

GREENWICH OBSERVATORY—JUNE TO AUGUST.

Year.	TEMPERATURE.		Number of days with Maximum at or above 80° F. (Normal = 18.)	SUNSHINE.	
	(Mean Maximum + mean Minimum).	Difference from Normal, 1841-1932.		Total.	Difference from Normal, 1881-1915.
	°F.	°F.		Hrs.	Hrs.
1876	64.2	+2.0	28	616	+21
1887	64.2	+2.0	27	715	+120
1899	64.7	+2.5	20	756	+161
1911	65.9	+3.7	37	819	+224
1921	64.2	+2.0	22	686	+91
1933	65.6	+3.4	31	698	+103

There is reason to believe that the sunshine values given for 1876 and 1887 may be substantially too low; by the middle of the "nineties" the sphere of the recorder had deteriorated in such a manner as to involve serious loss of trace, and comparable statistics are not considered to have become available until 1897, when a new sphere was taken into use.

In the absence of any quantitative data for sunshine prior to 1876, the full comparison cannot be extended further back. We may note, however, that the sunspot minima of 1867, 1856 and 1843 were each preceded at intervals of one to three years by summers which were described in contemporary literature as "fine and bright," and which records show to have been decidedly drier than usual. The period from June to August in 1864 was marked by acute drought, England and Wales as a whole receiving only 50 per cent. of the normal rainfall during the three months, according to the data published on pp. 300-5 of *British Rainfall*, 1931. From the same source it may be

\* See *Meteorological Glossary*, 2nd Edn., p. 108.

ascertained that the June—August precipitation was 15 per cent. below normal in 1854, and 10 per cent. below normal in 1842. Of the three summers just mentioned, only that of 1842 was particularly warm at Greenwich, on the basis of mean temperature; each of them gave approximately the average number (13) of days with maxima in the "eighties," there being 15 of these in 1864, 11 in 1854, and 17 in 1842.

The whole matter is one for future investigation; at present our records do not cover a long enough period to enable definite conclusions to be drawn. Meteorologists are well aware how far the arm of coincidence can reach, and few of them are likely to dispute that the association of outstandingly well-behaved summers with the near approach of six consecutive minima of the sunspot cycle might conceivably come within its comprehensive span. Nevertheless, it is tempting to assume that the connexion is a real one, and that the memorable summer of 1933 is somehow linked up with the solar processes conducing to a sunspot minimum in 1934 or 1935.

It is to be feared that even if such a relationship can eventually be proved, it will give us no great help in solving the problems of seasonal forecasting, since the phases of the sunspot cycle are inconstant and, in the light of existing knowledge, unpredictable. The famous 11-year (or 11.25-year) "period" is merely the average length of the interval between successive peaks of solar activity. How this may vary can be judged from a study of Wolf and Wolfer's tables, which show that there were maxima in 1830 and 1837, but none from 1787 to 1804; a maximum may be separated from the ensuing minimum by as many as 11 years (*e.g.*, 1787-1798), or by as few as three years (*e.g.*, 1830-1833).

A recent investigation by W. B. Schostakowitsch, of the Soviet Meteorological Service, into sunspot relationships with different meteorological elements over the various continents and oceans has led him to the conviction that markedly more precipitation falls over the earth as a whole at times of spot maximum than at times of spot minimum. If this is so, it seems quite logical to infer a decrease of cloudiness, and consequently an increase of sunshine, at the latter epoch, though so far as England is concerned it is evidently not the actual years of spot minimum that give most insolation.

Should it ever be shown that southern England does regularly experience a particularly bright and warm summer at an interval ranging from one year to three years before the minimum of solar activity, this varying period of separation between the two phenomena might perhaps be explained on the assumption that the actual position of the spotted area is involved in the connexion. It is known that with the advance of each pulse in the solar cycle there is (or has been as far back as the middle of last century) a fairly steady decrease in the mean latitude of

the spots. Two years before minimum it is normally the zones from  $6^{\circ}$  to  $9^{\circ}$  north and south of the sun's equator that are chiefly affected, but these limits are subject to fluctuation, and the penultimate year of one cycle may be characterised by the same mean spot-latitude as the ante-penultimate year of the next cycle. Since both auroræ and magnetic storms are believed to originate in emanations from restricted areas of the solar envelope, it does not seem unreasonable to suppose that, through some unknown train of events, southern England's summer weather may be favourably influenced by a concentration of activity within  $6^{\circ}$  to  $9^{\circ}$  on either side of the solar equator.

In view of Mr. Kershaw's belief that a three-and-a-half or four years periodicity can be traced in the sunshine records for English stations, it may be worth while recalling that in 1907 W. J. S. Lockyer detected a cycle of approximately 3.75 years for solar prominences.

E. L. HAWKES.

### Discussions at the Meteorological Office

The subjects for discussion for the next two meetings will be:—  
November 27th, 1933.—*The maintenance of the earth's electric charge.* By E. Schweidler (Probleme der kosmischen Physik XV, Hamburg, 1932) (in German). *Opener*—Dr. H. Spencer Jones.

December 11th, 1933.—*Sounding balloon ascents at Abisko from 1921 to 1929.* By B. Rolf (Stockholm, Medd. Meteor. Hydr. Anst. Vol. 5, No. 5, 1932) (in French). *Opener*—Major A. H. R. Goldie, M.A.

### Correspondence

To the Editor, *The Meteorological Magazine.*

#### A Meteor Shower

Last night, October 9th, 1933, a most amazing "meteor shower" was observed at Eskdalemuir. I think it worth while forwarding you a description, as practically the whole of England and the extreme east of Scotland were under a thick cloud sheet, so that the phenomenon would probably not be observed in these parts. As regards the British Isles as a whole, it would probably have been observed in Ireland and western Scotland. It may just possibly have been seen at Edinburgh.

The shower was first observed at 19h. 45m. G.M.T. by Messrs. W. I. Jones and W. A. C. Webb, who drew my attention to it, and we watched it for a considerable time. The sky to the south and east (nearly to the zenith) was covered with nimbus and alto-stratus cloud, the latter presenting a definite edge. The alto-stratus was associated with a "cold front" which had



passed Eskdalemuir at 17h. 30m. Detached cumulus cloud was visible low down in the west, but between the two banks of cloud the sky was clear. The alto-stratus was slowly retreating eastwards.

Literally thousand of meteors, some very bright, were observed between 19h. 45m. and 20h. 30m. They were observed at practically all parts of the visible sky, and their paths, if produced backwards, seemed to radiate from an area in the sky in the constellation of Draco near Beta Draconis. The tracks of the meteors were mostly not very long and appeared at all parts of the sky to within about  $10^{\circ}$ - $15^{\circ}$  of the horizon.

The meteors were most numerous and bright during the first half of the period quoted above, thereafter decreasing in frequency and in the number of bright meteors. By 20h. 30m. a sheet of cumulus had spread up from the south-west and covered the sky. Thereafter there were partial clearances and occasional meteors could be seen. At 21h. 10m. the sky cleared considerably and from then until 22h. 15m. occasional meteors were seen. One or two of these latter ones did not appear to radiate from the area in the constellation of Draco.

L. DODS.

*The Observatory, Eskdalemuir, Langholm. October 10th, 1933.*

[Meteors were also reported on the same day from the whole of Europe (from Ireland and Portugal to Russia), the Mediterranean and the Gold Coast in  $5\frac{1}{2}^{\circ}$  N. The meteors were not especially bright but attracted attention by their numbers; according to Mr. R. Forbes-Bentley at Malta they numbered about 22,500. They left yellowish trails. Mr. A. King in *Nature* defines the radiant point on the mean of four observations (Eskdalemuir, Armagh, Omagh and Malta) as having an azimuth of  $264.5^{\circ}$  and an elevation of  $54.5^{\circ}$ . At Agona Swedru Mr. L. J. Packham described the direction of motion as from north to south.

Mr. C. P. dos Santos, Lloyd's Agent at Faro, Portugal, writes that at Faro "the shooting stars irradiated from a fixed spot in the sky, somewhat situated in the midst of the constellation of Ursa Minor, the stars following the trajectories of north-south, north-south-east, north-south-west. The phenomenon here in Faro practically lasted from 8 p.m. to 10 p.m., the brilliancy of the shooting stars not being very great, and it was ensued by a thick, white fog, spreading all over the sky."—*Ed., M.M.*]

### The Summer of 1933 at Newquay

As we have been enjoying an excellent summer it will be interesting to see how it compares with previous good ones. For purposes of comparison I take summer to be the four months June to September.

We will commence with a table giving the main statistics for fine summers.

	Mean Max.	Mean Min.	Rainfall.	Rain days.	Sunshine.
	°F.	°F.	in.	No.	hrs.
1898	64.8	56.3	5.05	98	655
1899	67.0	56.8	7.50	48	946
1911	67.7	54.0	7.01	42	1,028
1921	66.3	55.1	6.09	38	878
1926	65.1	55.4	7.83	47	756
1933	66.4	55.4	8.16	53	853

In our climate (which we do not appreciate as we should) there is no such thing as weather repeating itself. So we find the good summers vary considerably and that no two are alike. 1899 and 1911 are distinctly the best. 1887, the first jubilee year, was perhaps even better; but local data are not available. 1898 was very dry, but comparatively cool and with a lack of sunshine. 1921 was very considerably helped by a very dry and sunny June and a very hot July. 1933 compares fairly well with 1926.

The characteristics of this summer have been its evenness, no month having been very hot or dry or sunny, and that the rainfall has been in five distinct spells, doing, I imagine, the greatest good and least harm for the amount of rain. For the gardens the rainfall has been almost perfect and their produce has been plentiful and of excellent quality and the various crops spread over a considerable period. The early farmer was not pleased with the rainfall in August; but he was compensated by the drought from August 29th to September 16th, which also enabled the "afternoon farmer" to finish harvest almost neck and neck with him.

The holiday maker seems to have been perfectly satisfied and many have prolonged their stay on account of the good weather. I did not notice many sun-blistored arms; perhaps the much talked about and boosted ultra-violet rays were less virulent than in some other summers. There were very many warm, but very few really hot days and few cool days.

Another point was the absence of any strong winds to damage the crops. The only complaint I have heard is that a drop more rain in September would have been good for the "roots."

I have been asked what is the probability of this good summer being followed by a hard winter and a poor summer next year. My reply has been that I may be a fool, and probably am; but I am not a long-period weather prophet.

C. C. VIGORS.

*Marous Hill, Newquay. October 23rd, 1933.*

### The Hot Summer and the Scottish Snowbeds

Papers on the permanent (!) Scottish snowbeds appeared in this magazine, Vol. 40, 1905, and in the *Geographical Journal*, Vol. 27, May, 1906, the former by the writer of this note, and the latter by the late V. H. Gatty. The articles dealt with the snowbed in the Observatory Gully of Ben Nevis which had never been known to melt. A similar snowbed exists in the Cairngorms in the Garbh Choire of Braeriach, where snow has never in living memory been known to be absent.

It seemed to me that the hot summer coupled with a low snowfall last winter in the Highlands warranted a careful investigation this autumn of these snowbeds. Though unable to go north myself I have ascertained from kindly Scottish correspondents that the Garbh Choire snowbed under Braeriach was still in existence on September 17th but had completely gone by October 1st, for the first time in memory. With regard to the Ben Nevis district information about the snowbed in the Observatory Gully is conflicting. On September 22nd, however, there was still a small patch of snow remaining under Aonach Beag (4,060 ft.), which I had noted some 16 years ago and photographed from above, and at the time had thought it looked as large or larger than the Ben Nevis bed. This was probably the case. Whether it entirely melted, I have not been able to find out, but if it did disappear there could hardly have been more than a fortnight before fresh snow would have covered it.

Thus the Braeriach snowfield of the Cairngorms can no longer be regarded as permanent although it may quite likely disappear only once in fifty years.

R. P. DANSEY.

*Kentchurch Rectory, Hereford. October 25th, 1933.*

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### Spells of Sunshine

I thank Mr. Bilham and Mr. Carter for their response to my letter on the above subject which appeared in the April *Magazine*. With Mr. Bilham I agree as to the use of the word *spell* instead of *period*, and with Mr. Carter in substituting 29 for 30 days.

When I suggested the spells I had in mind simple definitions which would be applicable to the whole country just as the various definitions for rainfall are uniform throughout. The definitions now suggested vary for every station in the country and are complicated. Each station has a different "maximum possible" which is the basis of the scheme as now amended. Such would involve considerable labour, and can be done in two ways (a) by graphical method, and (b) by the preparation of tables for each station.

(a) The graph would show the curve of the "quarter

possible," "half possible" and the normal and each day's sunshine, and would have to be plotted down.

(6) A table for each station would be prepared from a graph and would show for each day "possible," "half possible," "quarter possible" and normal. Thereafter each day would be classified.

To the trained mind this is not an objection, but if classification is to be adopted generally it may have to be carried out by observers who have not the experience to follow such a method.

During my leisure, which is not extensive, I propose to investigate the scheme as it now stands amended by Mr. Carter, and later will supply a note of my results which will cover a period of fully 30 years.

WILLIAM DUNBAR.

17, *Kay Park, Kilmarnock. October 30th, 1933.*

### **Rainbow preceding Waterspout**

I notice in Mr. J. Crichton's article on a "Waterspout in Kirkwall Bay" in last October's issue of the *Meteorological Magazine* there is mention of a circular or halo rainbow preceding the waterspout. I should like to mention that there was a similar occurrence at Eastbourne following soon after the passage of a roll cloud described in last June's *Meteorological Magazine*. This rainbow was low down in the sky close to the horizon out at sea and resembled a coloured spot-light and the diameter was about twice the size of a full moon when seen overhead.

J. MONGER.

17, *St. James' Mansions, London, N.10. October 26th, 1933.*

## **NOTES AND QUERIES**

### **Memorial to Buys Ballot**

A Committee has been formed in Kloetinge (Holland) for the purpose of erecting a Memorial to Buys Ballot, who was born in the year 1817, and who was one of the first pioneers in meteorology.

As Buys Ballot's reputation is world wide, it has been suggested that many of his admirers would like to contribute towards the erection of the memorial. It is proposed to erect the memorial at Kloetinge, being his birthplace.

All subscriptions should be sent to C. Kouwenmaker, Secretary, Comité Gedenkteecken "Buys Ballot," Kloetinge, Holland.

### **Agricultural Meteorological Conference, 1933**

After the lapse of a year in consequence of the economic crisis the series of annual conferences of workers in Agricultural Meteorology was resumed on October 6th, when a well-attended meeting was held in the Meteorological Office, South Kensington.

The conferences are organised by the Ministry of Agriculture and Fisheries in connexion with the "Crop-weather" scheme inaugurated in 1923.

In a paper entitled "The Growers' Year Book," Sir Napier Shaw expressed the view that agricultural meteorologists are greatly hampered by having to refer their data to the arbitrary and inappropriate divisions of the Gregorian calendar, and proceeded to outline a scheme for dividing the year into four quarters centering at the solstices and equinoxes. Each quarter would comprise thirteen weeks beginning on fixed dates, grouped into "chapters" of four or five weeks. The year would be regarded as beginning on November 6th, and it was further proposed that the weekly values of rainfall, sunshine and accumulated temperature should be integrated week by week from that date. Sir Thomas Middleton spoke in support of the scheme.

Prof. H. V. Blackman read a paper on "Some Effects of Temperature on the Growth of Plants," in which he gave some interesting examples of the effects of temperature changes on the growth of cereals and on the flowering of orchids and other plants.

Dr. R. A. Fisher dealt with the subject of "Sampling Observations," with special reference to the Ministry's scheme for precision observations on the wheat crop. The question of sampling is of great importance in any series of observations of this character, and Dr. Fisher's lucid exposition was followed with much interest.

In the absence of the author, copies of Mr. W. Herrod-Hempsall's paper on "The Weather and Bees" were circulated. The direct and indirect effects of weather on bees are interesting and important, as may be illustrated by the following quotation:—"The effect to the farmer, through the operation of adverse weather conditions on the bumble bee, may be appreciated when it is realised that this bee is practically the sole agent responsible for the pollination of the red clover. A paucity of bumble bees means meagre crops of red clover seed." It would be difficult to imagine a better illustration of the complexities involved in the problem of the relation between the weather and the crops.

The Conference was preceded by an instructional course, which was attended by more than twenty observers from crop-weather stations.

E. G. BILHAM.

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## Reviews

*Meteorology for Masters and Mates.* By Charles H. Brown.

As the title indicates, this book has been written primarily

for officers of the Merchant Navy, and it aims at providing all the information required to answer the questions on Meteorology set in the Board of Trade examinations, the syllabus of which is given at the beginning of the book.

The first chapter deals with the physical properties of the atmosphere, and especially refers to heat and the transmission of heat. It only touches very briefly on these fundamentals of weather, and it is considered the value of the book would have been enhanced had this section been treated at greater length.

The meteorological instruments used in ships are described in some detail in Chapter II, the descriptions being accompanied by excellent illustrations (except that of the thermometer screen, which shows a screen of the old fixed type instead of the modern portable screen); the hints on the exposure and handling of instruments given in this chapter should be particularly useful.

The following chapters deal successively with pressure and winds, cloud types and weather, tropical storms, ocean currents, optical phenomena, and organised Meteorology and the book concludes with a glossary of meteorological terms. Questions upon the subject matter included at the end of each chapter and a selection of examination questions given at the end of the book will assist the student in preparing for his examination. It is doubtful, however, whether an officer will derive any very definite ideas upon the actual physical processes of weather from a perusal of this book. These processes, a working knowledge of which is essential for any officer if he is to understand and appreciate the meteorological significance of the various phenomena encountered at sea, are only superficially dealt with. It is rather surprising, too, to find no reference to the modern conception of air masses and fronts, which are of considerable assistance in practical forecasting. The omission is doubtless due to the fact, also somewhat surprising, that no mention of these conceptions is made in the syllabus of the Board of Trade examination, but it serves to illustrate the inherent disadvantages of a text-book prepared to enable an officer to pass examinations rather than to give him a sound grounding for practising Meteorology at sea.

The book is very attractively printed and produced with ample illustrations, and fulfils its main object of covering the ground for the Board of Trade examinations.

L. G. GARBETT.

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### Books Received

*Bulletin de l'Observatoire de Talence (Gironde).* (Mensuel), Nos. 1-12, 1932.

*Anales del Observatorio Nacional de San Bartolomé en los Andes Colombianos.* Observaciones meteorológicas de 1930. Bogotá, 1932.

*Royal Alfred Observatory, Mauritius.* Results of magnetical and meteorological observations for July to December and Year 1931, and January to August, 1932; Port Louis 1931, 1932 and 1933.

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## Obituary

*Sir Alexander Houston, K.B.E., C.V.O., M.B., D.Sc., LL.D., F.R.S.*—We regret to learn of the death of Sir Alexander Houston on October 29th last, at the age of 68. Sir Alexander had been Director of Water Examination of the Metropolitan Water Board since 1905 and the chemical and bacteriological examinations carried out by this department have played no small part in securing the health of the vast population supplied with water by the Board. His annual reports, which made such pleasant reading (see reviews in earlier numbers of this magazine, Vol. 60, 1931, pp. 192-3, and Vol. 63, 1928, pp. 193-4), revealed his interest in meteorology.

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We regret to learn of the death on August 18th, 1933, at the age of 77 years of Dr. Hemmo Bos of Wageningen, founder and editor of the international journal *Acta Phenologica*, and initiator with his brother, P. R. Bos, of the Dutch phenological network in 1894.

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We regret to learn of the death in an accident on July 27th, at the age of 52, of Frank W. Peek, one of the world's foremost electrical engineers and an authority on the effects of lightning. His death interrupted preparations for an exhaustive study of electrical disturbances over New York by means of a series of lightning meters on the tower of the Empire State Building.

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## News in Brief

On October 9th, Sir Henry Lyons, F.R.S., retired from the office of Director of the Science Museum, which he has held since 1920. The occasion was marked by a ceremony on October 11th at which Lord Irwin, President of the Board of Education, presented a writing table, and an address was read by Sir Richard Glazebrook expressing the appreciation and admiration of the Advisory Council of the Science Museum for the work which Sir Henry has done in making the Museum a foremost place among institutions of its kind.

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Professor Sydney Chapman, professor of mathematics in the Imperial College of Science, will deliver a lecture (open to the public) on "The Sun's Magnetism" before the Institution of Professional Civil Servants at the Royal Society of Arts, John Street, Adelphi, London, W.C.2, on November 24th, at 5.30 p.m.

## The Weather of October, 1933

Pressure was above normal from Alaska, Canada and north-east United States across the North Atlantic, South Greenland, Iceland, north-west British Isles and central Scandinavia to Russia, western Siberia, south-east Europe and most of the Mediterranean, the greatest excesses being 8.5 mb. at 50° N. 50° W. and 5.6 mb. at Ekaterinburg. Pressure was below normal over the rest of the United States, Bermuda, the Azores, Madeira and from Portugal to Denmark, and over northern Scandinavia, Spitsbergen and between the Black Sea and the Caspian Sea, the greatest deficit being 3.7 mb. at Madeira. Temperature was above normal over western Europe and rainfall variable—in western Sweden and southern and eastern Gothland 50 per cent. above normal.

The weather of October over the British Isles was mild and unsettled during the first fortnight, with some unusually high minimum temperatures and stormy and cold during the last week. From the 1st to the 6th a high-pressure area was situated over the country, giving mainly cloudy weather with slight local drizzle, and in the mornings and evenings much mist or fog (except in Ireland). Much sun was experienced on the southern coast from the 4th to 6th, 10.5 hrs. bright sunshine being recorded at Calshot and Weymouth on the 4th. On the 6th the high-pressure area gave way to two depressions, temperature rose somewhat, reaching 70° F. at Huddersfield and Greenwich on the 6th, while minimum temperatures in the screen did not fall below 61° F. at Brighton and Eastbourne on the 8th. Rain fell generally, becoming heavy locally on the 7th, when 2.25 in. occurred at Treacastle (Brecon). From the 9th to 11th a deep depression moved north-eastwards along our western seaboard, giving strong winds to gales mainly between S. and W. on the coasts and heavy rain generally: 3.85 in. fell at Llyn Fawr (Glamorgan) and 3.04 in. at Treacastle (Brecon). Minimum temperatures were high during this time, 62° F. being recorded at Worthing, Brighton and Eastbourne on the 10th. Thunderstorms occurred at Gorleston and Rhayader on the 8th, and hail was reported locally. In the rear of this depression a bright sunny day was experienced on the 12th and temperature fell somewhat. From then until the 16th depressions moved eastwards to the north of the British Isles and weather was unsettled with rain locally and SW.-W. winds. Temperature continued to fall and hail was reported from many places on the 16th and snow on the Scottish hills on the 17th. On the 17th and 18th a ridge of high pressure between two depressions passed across the country and mainly fair weather (except in the north) prevailed on the 17th and also in the eastern districts on the 18th. On the 18th and 19th the winds backed to S. and rain set in again, mainly moderate but very heavy locally, 3.86 in. were recorded at Pofanny (Co. Down) on the 18th. From the 20th to 26th pressure



was high to the north of the British Isles, while a depression over the Bay of Biscay drifted to the North Sea. Mainly cloudy unsettled conditions prevailed during this time but there was some heavy rain in north England and south Scotland on the 22nd and much mist or fog on the 23rd and 24th. On the 25th and 26th the high pressure to the north-east spread more over the British Isles giving mainly fair sunny weather on those days. But with the onset of the cold northerly winds temperature fell considerably and stormy wintry weather was experienced from the 26th to 28th, while the complex low pressure area over the North Sea grew deeper. Strong winds or gales were recorded from most parts of the coasts. Thunderstorms were widespread on the 26th to 28th, and sleet, snow and hail were recorded, the snow was heavy in the north and midlands, and in scattered showers reached as far south as Hampstead. Maximum temperatures did not exceed 40° F. at Marchmont and Oban on the 27th and Gorleston on the 28th, while a minimum of 17° F. on the ground was recorded at Rhayader on the 28th. On the 29th and 30th the depression moved away first southwards, then north-eastwards, and conditions became milder and calmer, though still unsettled until the 31st. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	42	—44	Liverpool	79	— 7
Aberdeen	66	—29	Ross-on-Wyo	86	— 6
Dublin	78	—26	Falmouth	89	—27
Birr Castle	74	—24	Gorleston	100	— 9
Valentia	83	—18	Kow	108	—110

The special message from Brazil states that the rainfall distribution was irregular over the whole country with averages 0.20 in., 0.59 in. above normal in the northern and southern regions respectively and equal to normal in the central regions. Four anticyclones passed across the country. The coffee, cocoa and mattee crops are in generally good condition. At Rio de Janeiro pressure was 0.8 mb. above normal and temperature equal to normal.

*Miscellaneous notes on weather abroad culled from various sources.* Storms occurred generally over the Ardennes, the Gard and the Vaucluse departments in southern France about the 9th followed by floods, and much damage and some loss of life was caused by a storm in Belgium on the 11th. An unusually early cold spell occurred in Russia during the first part of the month, damaging the crops. A foot of snow had fallen on the Swiss mountains down to the 4,500 ft. level by the 19th, and the higher passes were closed to vehicles. Floods occurred at Millau

(south France) and in the low-lying parts of Saint Affrique on the 23rd, and heavy rains caused floods on the 24th at Renteria between San Sebastian and the frontier, several people being drowned. Widespread damage was caused by a storm on the Belgian coast on the 26th. A waterspout which struck the island of Ivar, off the Dalmatian coast, completely wrecked the three villages of Dubavica, Milna and Velo Grabiji. Snow fell in north Italy at the end of the month and heavy falls of snow were reported about the same time in many parts of France, including the Vosges and the Alps. (*The Times*, October 10th-30th, and *Yorkshire Post*, October 26th.)

A severe storm occurred off Singapore on the 22nd during which a steamer foundered. (*The Times*, October 25th.)

The disastrous drought which extends throughout South Africa, except for a narrow belt round the coast, continued during October. It is estimated that 10,000,000 sheep have been lost. Kenya has also suffered from drought, conditions being most severe in the district south-east of Lake Rudolf. (*The Times*, October 19th-November 3rd.)

Snow began to fall heavily in central and eastern Canada on the 24th, and on the 25th, what was reported as the earliest and worst October blizzard on record was experienced. Heavy snow and gales caused much damage in the States of Vermont, New York, Minnesota and Illinois on the same day. A storm lasting 72 hours and accompanied by heavy rain stripped 150,000 barrels of apples from the trees in Annapolis Valley, Nova Scotia. A hurricane passed close to the west end of Jamaica on the 2nd and 3rd and there were floods with heavy rain and high wind elsewhere on the island, much damage being done to the banana crop. On the 4th a hurricane accompanied by heavy rain passed across Cuba and many small craft were sunk in Havana harbour. A storm passed over the southern part of Jamaica on the 28th, reaching hurricane force when it struck the west end of the island during the night. Twenty people were killed, and it is estimated that 15,000,000 banana trees were destroyed. In the United States temperature was generally above normal in the Mountain Region and along the Pacific Coast, below normal rising to above normal along the Atlantic coast and in the Gulf States, and variable in the middle States. Rainfall was on the whole below normal except in Florida. (*The Times*, October 6th-November 2nd, and *Washington, D.C., U.S. Dept. Agric. Weekly Weather and Crop Bulletin*.)

### General Rainfall for October, 1933

England and Wales	...	108	} per cent of the average 1881-1915.
Scotland	...	107	
Ireland	...	88	
British Isles	...	100	

## Rainfall: October, 1933: England and Wales.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>Lonl</i>	Camden Square .....	1.58	00	<i>Leis.</i>	Thornton Reservoir ...	2.89	103
<i>Kent</i>	Tenfolden, Ashenden....	1.52	44		Belvoir Castle.....	2.74	101
"	Folkestone, Boro. San.	2.14	...	<i>liut</i>	Ridlington .....	2.53	90
"	St. Peter's, Hildersham	...	...	<i>Lincs.</i>	Boston, Skirbeck .....	3.18	116
"	Eden'ldg., Falconhurst	2.01	56	"	Cranwell Aerodrome ...	2.59	90
"	Sevenoaks, Speldhurst	2.01	...	"	Skegness, Marine Gdns	2.73	100
<i>Sus.</i>	Compton, Compton Ho.	2.23	49	"	Louth, Westgate .....	3.08	95
"	Patching Farm .....	1.79	45	"	Brigg, Wrawby St. ...	5.14	...
"	Eastbourne, Wil. Sq.	2.80	67	<i>Notts</i>	Worksop, Hodscock ...	4.32	164
"	Heathfield, Barklye ...	2.04	49	<i>Derby.</i>	Derby, L. M. & S. Rly.	3.91	150
<i>Hants.</i>	Ventnor, Roy. Nat. Hos.	2.64	67	"	Buxton, Terr. Slopes	7.00	142
"	Fordingbridge, Oaklands	1.83	44	<i>Ches.</i>	Runcorn, Weston Pt. ...	4.00	116
"	Ovington Rectory .....	2.81	69	<i>Leices.</i>	Manchester, Whit Pk.	4.58	130
"	Shorborne St. John ...	1.81	51	"	Stonyhurst College ...	5.25	117
<i>Herts.</i>	Wolwyn Garden City ...	1.48	...	"	Southport, Hesketh Pk	3.87	112
<i>Bucks.</i>	Slough, Upton .....	1.50	57	"	Lancaster, Grog Obsy.	5.04	122
"	H. Wycombe, Flackwell	1.73	...	<i>Yorks.</i>	Wath-upon-Dearne ...	4.03	107
<i>Oxf.</i>	Oxford, Mag. College...	1.50	54	"	Wakefield, Clarence Pk.	4.10	143
<i>Nor.</i>	Pitsford, Sedgebrook...	1.70	63	"	Oughtershaw Hall.....	5.30	...
"	Oundle.....	1.80	...	"	Wetherby, Ribston H.	3.88	120
<i>Beds.</i>	Woburn, Crawley Mill	1.44	54	"	Hull, Pearson Park ...	4.91	101
<i>Cam.</i>	Cambridge, Bot. Gdns.	1.52	64	"	Holme-on-Spalding ...	5.56	...
<i>Essex.</i>	Chelmsford, County Lab	1.53	62	"	West Witton, Ivy Ho.	8.06	82
"	Lexden Hill House ...	1.88	...	"	Felixkirk, Mt. St. John	4.20	149
<i>Staff.</i>	Haughley House.....	1.89	...	"	York, Museum Gdns.	3.33	124
"	Campsea Ashle.....	2.06	78	"	Pickering, Hungate ...	4.88	180
"	Lowestoft Sec. School	3.58	128	"	Scarborough .....	4.04	148
"	Bury St. Ed. Westley II.	2.46	90	"	Middlesbrough .....	3.88	120
<i>Norw.</i>	Wells, Holkham Hall	3.74	133	"	Baldersdale, Hury Res.	...	...
<i>Wills.</i>	Devizes, Highclere...	2.42	78	<i>Durh.</i>	Ushaw College .....	3.76	100
"	Calne, Castleway .....	2.41	75	<i>Nor.</i>	Newcastle, Town Moor	3.47	108
<i>Dor.</i>	Evershot, Melbury Ho.	3.02	65	"	Bellingham, Highgreen	3.44	88
"	Weymouth, Westham	1.81	56	"	Lilburn Tower Gdns...	4.51	122
"	Shaftesbury, Abbey Ho.	2.13	55	<i>Cumb.</i>	Carlisle, Scaloby Hall	2.40	72
<i>Devon.</i>	Plymouth, The Hoe ...	3.49	88	"	Borrowdale, Scathwaite	9.00	79
"	Holne, Church Pk. Cott.	7.23	110	"	Borrowdale, Moraine...	8.19	...
"	Telgmouth, Den Gdns.	2.81	60	"	Keswick, High Hill...	5.76	103
"	Cullompton.....	3.18	77	<i>West.</i>	Appleby, Castle Bank	5.29	152
"	Sidmouth, Sidmount...	2.37	64	<i>Mon.</i>	Abergavenny, Tareh...	5.71	136
"	Barnstaple, N. Dev. Ath	4.88	107	<i>Glam.</i>	Ystalyfera, Wern Ho.	11.88	172
"	Dartm'r, Cranmere Pool	9.00	...	"	Cardiff, Ely P. Stan. ...	4.92	102
"	Okehampton, Uplands	6.41	108	"	Treharbert, Tynywaun	11.34	...
<i>Corn.</i>	Redruth, Trowirgle ...	8.64	165	<i>Carm.</i>	Carmarthen Friary ...	8.25	144
"	Penzance, Morrab Gdn.	6.58	140	<i>Pemb.</i>	Haverfordwest, School	3.16	151
"	St. Austell, Trevarua...	7.05	134	<i>Card.</i>	Aborystwyth .....	5.39	...
<i>Soms.</i>	Chepton Mendip .....	3.27	68	<i>Rad.</i>	Birm W.W. Tŷmynydd	7.09	116
"	Long Ashton .....	2.84	76	<i>Mont.</i>	Lake Vyrnwy .....	0.80	111
"	Street, Millfield.....	2.70	85	<i>Flint.</i>	Sealand Aerodrome ...	3.46	115
<i>Glos.</i>	Blockley .....	2.52	...	<i>Mer.</i>	Dolgelly, Bontddu ...	8.19	134
"	Cirencester, Gwynfa ...	2.90	90	<i>Carn.</i>	Llandudno .....	3.61	100
<i>Here.</i>	Ross, Birchlea.....	3.78	118	"	Snowdon, L. Llydaw ...	15.87	...
<i>Salop.</i>	Chnrch Stretton.....	5.18	143	<i>Ang.</i>	Holyhead, Salt Island	3.48	87
"	Shifnal, Hatton Grange	4.71	166	"	Llŷgwy.....	4.24	...
<i>Staff's.</i>	Market Drayton, Old Sp.	4.82	157	<i>Isle of Man</i>			
<i>Worc.</i>	Ombersley, Holt Lock	4.08	151		Douglas, Boro' Cem. ...	5.80	117
<i>War.</i>	Alcester, Ragley Hall.	3.64	133	<i>Guernsey</i>			
"	Birmingham, Edgbaston	5.00	180		St. Peter P't. Grange Rd.	2.88	68

## Rainfall: October, 1933: Scotland and Ireland.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>Wig.</i>	Pl. William, Mongelath	2.55	64	<i>Suth.</i>	Molviach	3.87	105
	New Luce School.....	4.10	80		Loch More, Achary...	0.88	127
<i>Kirk.</i>	Dalry, Glendarroch ...	3.60	70	<i>Gaith.</i>	Wick	3.80	133
	Carsphairn, Shiel .....	5.91	83	<i>Ork.</i>	Deerness	2.03	69
<i>Dumf.</i>	Dumfries, Crichton, R.I.	2.50	94	<i>Shet.</i>	Lerwick	4.07	103
	Eskdalemuir Obs. ....	3.70	69	<i>Cork.</i>	Callenagh Rectory .....	2.19	...
<i>Roxb.</i>	Braxhohm .....	4.19	123		Dunmanway Rectory ..	2.04	40
<i>Selk.</i>	Ettrick Manse .....	4.25	77		Cork, University Coll.	2.09	54
<i>Perth.</i>	West Linton .....	3.12	...		Ballinacura	2.41	59
<i>Berw.</i>	Marchmont House.....	3.63	95	<i>Kerry.</i>	Valentia Obsy.....	3.21	58
<i>E. Lot.</i>	North Berwick Res....	2.38	80		Gourhamoon .....	5.80	03
<i>Midl.</i>	Edinburgh, Roy. Obs.	2.25	82		Darvynano Abbey .....	3.35	07
<i>Lea.</i>	Auchtyfardle .....	3.13	...	<i>Wat.</i>	Waterford, Gortmore...	3.06	101
<i>Ayr.</i>	Kilmarnoek, Kay Pl. .	2.89	...	<i>Tip.</i>	Neungh, Oas. Lough ..	2.21	65
	Girvan, Plumore.....	4.20	84		Roscrea, Timoney Park	2.15	...
<i>Renf.</i>	Glasgow, Queen's Pl. .	3.04	93		Cashel, Ballinamona ...	2.12	59
	Greenock, Prospect H.	3.18	59	<i>Lim.</i>	Foynea, Coolmanes.....	2.18	59
<i>Bute.</i>	Rothsay, Ardenavdg.	3.93	...		Castloconnell Rec.....	2.04	...
	Dougarie Lodge.....	3.65	...	<i>Clare.</i>	Inagh, Mount Callan...	3.49	...
<i>Arg.</i>	Ardgour House .....	10.37	...		Broadford, Hurdlest'n.	2.08	...
	Glen Etive .....	...	...	<i>Wexf.</i>	Gorey, Countown Ho...	3.93	111
	Oban .....	3.49	76	<i>Kilk.</i>	Kilkenny Castle .....	...	...
	Poltalloch .....	...	...	<i>Wick.</i>	Rathnew, Clonmannon	3.36	...
	Inveraray Castle .....	6.89	98	<i>Carl.</i>	Hacketstown Rectory..	4.84	127
	Islay, Ballulus .....	3.90	82	<i>Leix.</i>	Blandsfort House .....	2.70	77
	Mull, Benmore .....	13.30	...		Mountnellick .....	2.93	...
	Tiree .....	5.03	130	<i>Offaly.</i>	Birr Castle .....	2.11	73
<i>Kinr.</i>	Loch Laven Shuce .....	2.81	82	<i>Dublin.</i>	Dublin, FitzWm. Sq....	2.02	75
<i>Perth.</i>	Loch Dhu .....	5.40	70		Balbriggan, Ardgillan.	3.12	110
	Balquhiddier, Stronvar	5.52	...	<i>Meath.</i>	Boavapare, St. Cloud ..	3.45	...
	Oriell, Strathearn Hyd.	3.06	93		Kells, Headfort.....	2.70	81
	Blair Castle Gardens...	3.78	122	<i>IF. M.</i>	Monte, Coolators .....	2.78	...
<i>Angus.</i>	Kottbus School .....	3.41	108		Mullingar, Belvedere...	2.75	88
	Pearso House .....	4.38	...	<i>Long.</i>	Castle Forbes Gdns....	2.20	69
	Montrose, Sunnyside...	0.52	127	<i>Gul.</i>	Galway, Grammar Sch.	1.85	...
<i>Aber.</i>	Braemar, Bank .....	0.46	172		Ballynahinch Castle...	3.70	63
	Logie Coldstone Sch....	0.12	189		Alasoragh, Clonbroek.	3.10	80
	Aberdeen, King's Coll.	4.72	167	<i>Mayo.</i>	Blacksod Point .....	4.50	90
	Fyvie Castle .....	0.45	108		Mallanman .....	5.07	...
<i>Moray.</i>	Gordon Castle .....	6.33	202		Westport House.....	4.13	92
	Grantown-on-Spey.....	5.16	184		Dolphin Lodge .....	9.08	105
<i>Nairn.</i>	Nairn .....	2.96	120	<i>Sligo.</i>	Markree Obay .....	3.35	82
<i>Inver.</i>	Ben Alder Lodge.....	7.09	...	<i>Ferm.</i>	Finniskillen, Portora...	2.47	...
	Kilgusissie, The Broches	5.42	...	<i>Arm.</i>	Armagh Obay .....	2.00	73
	Inverness, Oldluthel R.	3.88	...	<i>Down.</i>	Fofanny Reservoir.....	7.32	...
	Loch Quoich, Loan.....	15.00	...		Seaford .....	3.74	105
	Glenquoich .....	...	...		Donaghadee, O. Sta....	2.15	74
	Arisaig, Fairo-na-Sgubh	5.62	...		Banbridge, Milltown...	1.91	69
	Fort William, Glasdrum	0.59	...	<i>Antr.</i>	Belfast, Cavohill Rd...	3.07	...
	Skye, Dunvegan .....	5.17	...		Aldergrove Aerodrome	2.34	78
	Barra, Skallary .....	5.09	...		Ballymena, Harryville	4.20	110
<i>R &amp; C.</i>	Alness, Ardross Castle	5.34	189	<i>Lon.</i>	Garvagh, Moneydig ...	4.27	...
	Ullapool .....	4.00	101		Londonderry, Creggan	4.30	117
	Achnashellach .....	7.93	99	<i>Tyr.</i>	Omagh, Edenfel.....	3.08	82
	Stornoway .....	4.80	93	<i>Don.</i>	Malin Head.....	3.77	...
<i>Suth.</i>	Lairg .....	4.59	123		Milford, The Manse ...	5.84	184
	Tongue .....	5.28	125		Killybegs, Rockmount.	3.41	...

### Climatological Table for the British Empire, May, 1933

STATIONS	PRESSURE		TEMPERATURE						PRECIPITATION			BRIGHT SUNSHINE			
	Mean of Day M.S.L.	Diff. from Normal	Absolute		Mean Values				Mean Cloud Amt.	Days	Diff. from Normal	Hours per day	Per cent. or more possible		
			Max.	Min.	Max.	Min.	1/2 max. and min.	Diff. from Normal							
														° F.	° F.
	mb.	mb.	° F.	° F.	° F.	° F.	° F.	° F.	%	in.	in.				
London, New Obsy.	1015.1	-0.8	77	39	64.2	47.5	55.9	+2.5	48.8	6.6	1.83	0.11	14	5.6	86
Gibraltar	1015.8	-0.3	82	52	78.0	59.1	68.5	+1.6	58.6	81	0.11	0.11	2	5.6	86
Malta	1015.0	+0.5	87	55	69.5	59.1	68.5	+1.6	58.3	82	0.43	0.02	4	9.7	70
St. Helena	1014.3	+0.7	70	58	66.7	59.6	63.1	0.0	60.5	93	0.82	..	13	..	..
Freetown, Sierra Leone	1013.1	+1.9	93	70	89.5	76.3	82.9	+1.4	78.4	83	3.65	7.82	13	..	..
Legos, Nigeria	1012.3	+1.7	90	71	87.6	76.6	82.1	+0.3	77.4	85	7.7	4.14	15	6.8	55
Kaduna, Nigeria	1011.9	-0.8	100	68	90.5	72.6	81.5	+2.1	73.6	76	6.6	1.11	14	7.3	58
Zomba, Nyasaland	1019.1	+4.0	89	50	78.2	55.5	66.9	+1.1	59.4	4.5	0.09	0.95	2	..	..
Salisbury, Rhodesia	1018.5	-0.1	79	39	74.4	45.9	60.1	-0.5	52.6	1.3	0.00	0.48	0	9.5	84
Cape Town	1019.6	+1.5	82	39	67.7	49.3	58.5	-0.4	50.5	49	1.96	1.79	14	..	..
Johannesburg	1018.7	+0.9	78	25	67.8	48.2	58.0	+3.6	45.9	42	0.12	0.64	2	9.6	88
Mauritius	1015.3	-1.1	83	58	79.7	66.6	73.1	+0.5	69.6	72	6.4	1.17	23	8.7	78
Calcutta, Alipore Obsy.	1005.0	+1.5	100	70	94.1	77.2	85.7	-0.4	78.7	82	4.9	1.86	11*	..	..
Bombay	1006.4	+1.0	93	74	91.0	79.6	85.3	-0.5	77.9	76	5.5	2.85	4*	..	..
Madras	1006.0	+0.6	101	77	94.5	80.3	87.4	-2.4	79.1	70	7.5	0.07	0*	..	..
Colombo, Ceylon	1009.1	+0.7	88	72	85.7	75.9	80.8	-2.0	77.5	82	8.5	20.89	28	4.0	32
Singapore	1008.6	-0.1	93	73	88.7	75.3	82.0	0.0	78.5	79	5.1	6.29	14	6.1	50
Hongkong	1010.8	+1.7	90	71	84.0	75.1	79.5	+2.1	74.9	79	7.5	4.51	13	7.0	53
Sandakan	1009.2	..	93	75	89.1	76.4	82.7	+0.2	78.1	80	5.9	0.67	7	..	..
Sydney, N.S.W.	1015.5	-3.1	77	45	67.4	52.2	59.8	+1.0	54.1	73	4.1	5.89	10	6.7	64
Melbourne	1016.1	-3.1	70	38	61.1	46.8	53.9	-0.2	48.8	77	7.4	1.48	12	3.3	33
Adelaide	1017.3	-2.7	76	43	65.2	50.9	58.1	+0.2	52.8	71	8.3	2.62	16	3.8	37
Perth, W. Australia	1016.0	-2.4	87	45	69.2	52.7	60.9	+0.2	54.2	67	6.3	4.67	16	5.7	55
Coolgardie	1016.6	-2.8	82	39	68.5	48.2	58.3	+0.6	50.0	53	3.3	1.78	7	..	..
Brisbane	1016.9	-1.7	79	46	75.1	55.6	65.3	+0.7	58.4	65	4.1	0.55	3	7.5	70
Hobart, Tasmania	1011.9	-3.4	63	37	56.5	44.5	50.5	0.0	46.5	76	7.3	1.71	20	3.4	35
Wellington, N.Z.	1011.7	-3.9	62	37	55.7	45.6	50.7	-2.1	48.1	79	7.0	1.16	17	3.7	37
Suva, Fiji	1013.3	+0.6	86	68	81.7	72.0	76.9	+0.4	73.1	85	6.7	10.50	20	4.1	36
Apia, Samoa	1011.4	+0.3	88	72	86.2	74.7	80.4	+2.0	77.4	78	5.6	2.38	20	7.5	65
Kingston, Jamaica	1012.5	-0.6	91	68	87.7	73.2	80.3	+0.8	72.4	75	6.9	2.85	7	7.8	60
Grenada, W.I.	..	..	..	..	..	..	..	..	..	..	..	1.54	..	..	..
Toronto	1013.6	-1.3	83	35	66.8	48.0	57.4	+3.6	50.2	68	6.5	1.67	10	6.4	44
Winnipeg	1012.3	-1.5	84	27	67.0	42.4	54.7	+2.7	43.7	73	7.4	5.27	9	8.0	52
St. John, N.B.	1012.9	-1.0	76	28	56.7	39.9	48.3	+0.6	43.5	69	5.8	3.51	13	8.5	57
Victoria, B.C.	1015.5	-1.2	63	41	55.6	45.1	50.9	-2.1	47.6	83	7.5	1.50	16	6.8	45

\* For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen.

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# The Meteorological Magazine



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## Nature as Dramatist

A few years ago the usual Christmastide increase in the sale of novels, detective stories and other similar literature must have been appreciably lessened by the vast popularity of a small book which Sir James Jeans had written a few weeks before about the mysteries of the universe. And now, again, many a 7s. 6d. that might have gone to the purveyors of fiction will purchase instead a work of science by way of a Christmas offering. This time, however, it is not astronomy but meteorology that provides the counter-attraction. Within a fortnight of its publication Sir Napier Shaw's "The Drama of Weather" \* was hailed as "the book of the month" in the United States. Although he writes therein of signs and portents, the author does not himself assume the mantle of a prophet, and it will therefore be strange if his new work is not accorded at least as much honour in his own country as it has already received across the Atlantic.

"The Drama of Weather" may perhaps be succinctly described as a miniature of the "Manual of Meteorology" with all the difficult parts sifted out. This is not to say that anybody who is familiar with the four volumes of the Manual will find nothing further to interest or instruct him in the book under review. On the contrary, the author's lively imagina-

\* "The Drama of Weather." By Sir Napier Shaw. Size 8½ in. x 6 in. Pp. xiv + 260. *illus.* Cambridge University Press. 7s. 6d. net.

tion has enabled him to take an entirely fresh outlook on his subject, and to present it to his readers in a form as original as it is attractive. The title is no mere catch-phrase. Astronomers have recently suggested that the universe of space and time can only have been devised by a master mathematician: Sir Napier prefers to regard the weather as "the work of an accomplished dramatic artist," and from that germ of thought, given expression on the first page of the preface, the book grows logically to an organic whole. "If we would make out the forces acting upon the atmosphere," he writes, "we must ascertain the motion of its parts, an enterprise which implies nothing less and nothing more than realising the drama and forming a pageant to represent it. It is a task that has never been achieved, and weather will never be understood until it has been; but many separate parts of the stage have been scrutinised, and the information used for practical purposes." As further justification for his mode of treatment Sir Napier adds, in another place, "Every phase of the behaviour of the atmosphere recalls some characteristic of personality either of a man or a woman, sometimes of both."

Here, then, we have the underlying scheme of the work. As a spectator of the drama, the reader is led first of all to inspect the scenery and "effects"; a prologue, headed "Pageantry in the sky," describes or illustrates for him such things as the forms of clouds, atmospheric disorder and quietude, electrical discharge, the trickery of light and colour, visibility, mirage. Thence he proceeds, in Chapter I, to consider "Ideas of the drama ancient and modern," wherein is set forth an historical review of weather study from the earliest times, with sub-sections on matters ranging from agricultural meteorology, astrology and weather lore to the modern stress of public service. Chapter II ("The watchers: what they see and what they say"), and Chapter III ("The score") deal, in the main, with observations visual and instrumental, their use, presentation and interpretation. Herein are exhibited and explained the barometer, thermometer, rain gauge, and other tools of the meteorologist, together with the knowledge that he has acquired from them, as exemplified in maps of the distribution of pressure, temperature and rainfall over the globe, charts of the upper air, and such like. Chapter IV is entitled "The chorus. Rhythmic aspects of the records," and concerns itself chiefly with the various types of seasonal change in the climatic elements. In Chapter V—"The weather map presents the play"—we meet the protagonists in the drama, and learn how they enact their parts. This section of the book consists of three sub-divisions, devoted respectively to cyclones and anticyclones, with their nature, travel and weather associations, to synoptic charts, with their meaning and use, and to the "Norwegian duet for polar and tropical air with cyclonic accompaniment—fronts and

frontiers." Lastly, a three-page Epilogue—"spoken behind the scenes," having peered into the future and visualised for us the vortical cross-sections of the ideal weather map yet to come, sums up the whole drama and our present comprehension of it in a few suggestive paragraphs.

The book is characterised throughout by the same effortless lucidity and literary grace that differentiates all Sir Napier Shaw's later writings from so many other expositions of matters scientific. While the more abstruse conceptions of modern meteorology are naturally omitted, the harmless, necessary difficulties are nowhere shunned; but so deftly are they handled that the non-technical reader will find himself understanding them without being aware that his intelligence has been exercised. A good example of this is on pp. 104 and 105, where tables of an aspect rather forbidding to the uninitiated set out such important but supposedly perplexing details as the relationships of temperature with pressure and density of water-vapour and long-wave radiation from a black body. A footnote explains these with a graphic simplicity which must make their meaning clear to the most unambitious mind.

There is in these pages none of that despondency which has of late been rife amongst meteorologists of the younger school in regard to the future of weather forecasting. Such pessimism is doubtless but a temporary counterblast to the premature optimism of half a century ago, recalled by Sir Napier. The only use of any word like "melancholy" in the book occurs in reference to the paucity of our information as to rainfall over the oceans. On p. 77 the author has a gentle tilt at a vulnerable point in official procedure. As one concerned with the application of meteorology to agriculture, he would have the annual volume of the *Weekly Weather Report* begin with nature's phenological year early in November, instead of with March, as at present. But for how many subscribers to that publication did its chief appeal vanish when it ceased to appear week by week?

The stores of information which pack this work from cover to cover are plentifully leavened with both humour and literary allusion. Homer, Hesiod, Herodotus, Aristophanes, Aristotle, Theophrastus, the Books of Job and Enoch, the New Testament, Shakespeare, Shelley and Ruskin are only a few of the sources drawn upon. Sir Napier's innate modesty prevents him from allowing casual readers to suspect the extent of his own contributions towards the advance of the science. In one place is a reference to "a recent 'Manual of Meteorology'"; elsewhere there is reproduced from the first edition of "Forecasting Weather" the well-known sketch diagram for the distribution of wind, temperature and rain about the centre of a depression, without any hint that this, and what it stood for, were pre-war signposts to the later revision of ideas by the Norwegian school.



Incidentally, we are reminded by the author that Norway is not the only Scandinavian country to which meteorology owes much; Sweden, we are told, gave us isallobars and the nephoscope, in addition to the centigrade thermometric scale.

A popular section of the book should be that which accounts for the action of various "weather toys," such as the familiar "Jacky and Jenny" hygrometric chalet, the Old Dutch weather-glass, the chloride-of-cobalt butterflies and flowers which dock seaside shop windows in summer, and the new-fangled "humidor." We miss, however, an explanation of the so-called "storm-glass"—that sealed phial of camphor-in-alcohol, which is said to have been an accidental discovery of the old alchemists, and which, in spite of a prevalent belief to the contrary, is not dependent solely on temperature changes for its diverse forms of crystallisation. Perhaps Sir Napier will throw his search-light on this mysterious instrument in a later edition of his work.

There seems to be a surprising lack of unanimity as to the world's recorded extremes of low temperature. For the absolute surface minimum at Verkhoiansk  $-90^{\circ}$  F. is given on p. 184 of the volume under review, but  $-94^{\circ}$  F. or  $-93.6^{\circ}$  F. in the "Meteorological Glossary" and other official publications. The absolute upper-air minimum, over Java, is said by Sir Napier to be  $-135^{\circ}$  F. at 16 Km., by McAdie to be  $-133^{\circ}$  F. at 17 Km., and by the "Meteorological Glossary" to be  $-131.6^{\circ}$  F. at  $16\frac{1}{2}$  Km. As to the Verkhoiansk reading, Sir Napier's figure appears to be confirmed by a recent communiqué from the Soviet Meteorological Service relating to the establishment of a valley climatological station at an altitude of 2,000 ft. above M.S.L. in the Oimekon district of Siberia. This region, it is said, will probably prove to be the world's "cold pole"; a minimum of  $-85^{\circ}$  F. registered there in the "comparatively mild" winter of 1929-30 was noted as being "only  $5^{\circ}$  F. higher than the Verkhoiansk extreme," and this "record" of half-a-century's standing is thought likely to be broken before long.

It remains only to add that, like its astronomical precursor in rivalry with works of fiction as a Christmas attraction, "The Drama of Weather" has been admirably produced by the Cambridge University Press. Its price is no higher than that of the average novel; yet style, binding, paper, type, illustrations, are all excellent, the reproduction of the many cloud photographs, in particular, coming near to perfection. For the success of this book all meteorologists will echo the expression that Sir Napier himself employs on p. 101, in his advocacy of the Kelvin kilograd temperature scale,—*Prosit!*

E. L. HAWKE.

[ $-93.6^{\circ}$  F. is given as the absolute minimum temperature at Verkhoiansk for February, 1892, in *Annalen des Physikalischen Central-Observatoriums*, St. Petersburg, 1892, Teil 2.—Ed., M.M.]

## Notes on the Upper Air Observations at Reykjavik during the Polar Year.

A Dutch expedition established by Dr. Cannegieter obtained a valuable series of observations from aeroplanes at Reykjavik, in western Iceland, between September, 1932, and August, 1933. The complete discussion of these observations must await the publication of the full data for the Polar Year, when sounding balloon observations at a number of places will also be available. There must also have been many interesting points which can only be dealt with by a meteorologist who was on the spot. Some preliminary discussion is nevertheless worth while. The present note deals with the temperature, pressure and lapse rate at 4 kilometres, and with the differences between Reykjavik and Duxford.

Many of the aeroplane observations were broadcast by wireless and appear in the *Upper Air Supplement of the Daily Weather Report* between October 24th and August 31st. (Nearly all the broadcast observations were on separate days, but on six occasions there were morning and evening observations.) Owing to an initial misunderstanding of the code used for transmitting the observations a few of the earlier observations in the *Daily Weather Report* require correction. At the height of 3 to 5 kilometres, 1 Km. (3,280 feet) should be added to the published figures for October 24th, 25th, January 3rd, May 1st, and 1 Km. should be subtracted on November 22nd, 23rd, December 15th, January 18th. With the data so far available in England, it is impossible to treat each season separately, but the middle of April is a convenient division between the winter period and the spring and summer period. On April 12th the upper air temperature was the lowest of the series, but when observations were renewed after Easter, temperature had risen decidedly and never became really low again.

*A Statistical Summary of observations in Daily Weather Report.*

### (a) Winter period, 56 observations.

Sea level pressure	mean 1004mb.	standard deviation	17.5mb.
Pressure at 4 Km.	" 596mb.	" "	12.1mb.
Temperature at 4 Km.	" -8.8°F.	" "	0.4°F.
Fall of temperature from 3 to 4 Km.	" 10.2°F.	" "	3.6°F.
" " " 4 to 5 Km.	" 11.4°F.	" "	3.2°F.
Correlation co-efficient between temperature and pressure at 4 Km.	0.04		
" " " " at 4 Km. and sea level pressure	0.36		

### (b) Spring and summer period, 85 observations.

Sea level pressure	mean 1010mb.	standard deviation	9.0mb.
Pressure at 4 Km.	" 612mb.	" "	6.3mb.
Temperature at 4 Km.	" 12.3°F.	" "	0.7°F.
Fall of temperature from 3 to 4 Km.	" 9.5°F.	" "	2.2°F.
" " " 4 to 5 Km.	" 10.4°F.	" "	2.1°F.
" " " 5 to 6 Km.	" 10.5°F.	" "	2.0°F.
Correlation co-efficient between temperature and pressure at 4 Km.	0.54		
" " " " at 4 Km. and sea level pressure	0.07		

\* 42 observations only.

It is interesting to compare these figures with those given by W. H. Dines\* for England. The correlation co-efficients are lower in Iceland than in England. The standard deviations at 4 Km. are much the same, the figures for Iceland temperature being a trifle lower than for England. An interesting point is that the standard deviation of pressure falls off with height in Iceland, whereas in England it remains practically the same. Thus the effect of the lowest four kilometres is larger in Iceland. The mean lapse-rate at the heights considered is much the same as in England.

*Individual Cases.*—A study of the observations in conjunction with synoptic charts reveals the same general features as one would expect in similar situations in England. The lowest temperatures occurred in Arctic currents, the extreme at 4 Km. being  $-27^{\circ}$  F. at 18h. on April 12th. A lower figure has occasionally been observed in England. High upper air temperatures were observed in most anticyclones and in currents originating well to southward. (Genuine tropical air is rare in Iceland.) The extreme at 4 Km. was  $27^{\circ}$  F. at 18h. on June 27th, and also at 10h. on July 8th, the latter being a good example of a warm current in a depression. Inversions with dry air above them were common in anticyclones.

The most notable observation was at 15h. on January 3rd, when sea-level pressure was as low as 942 mb., probably the lowest for any upper air ascent yet made. Temperature at 4 Km. was  $-13^{\circ}$  F., an appreciably higher figure than that usually found in Arctic currents. Pressure at 4 Km. was 558 mb., or 38 mb. below the winter normal, whereas sea-level pressure was 62 mb. below normal. At the top of the troposphere the deviation was presumably less than at 4 Km. This example supports the conclusion I obtained for extremes of low or high pressure over England,† namely that in such cases the deviations at the top of the troposphere are about half those at sea level. Since the density is a function of both pressure and temperature, the result implies that the troposphere is normally cold in a deep depression and warm in a pronounced anticyclone, but that too large deviations of temperature in this sense are incompatible with extremes of sea-level pressure.

*Comparison with Duxford.*—Nearly simultaneously observations (within 3 or 4 hours) at Reykjavik and Duxford are available on 127 occasions. Interpolation is necessary to make a comparison either at fixed heights or fixed pressures, but errors due to this cause can only be small. The mean temperature difference for the whole year at 4 Km. was  $11.0^{\circ}$  F., with a standard deviation  $11.4^{\circ}$  F. For the winter period the mean difference was  $16.1^{\circ}$  F., with standard deviation  $13.1^{\circ}$  F., and for the summer period the mean was  $7.3^{\circ}$  F., with

\* London, Meteorological Office. *Graphs. Publ. No. 13.*

† London, *Mem. R. Meteor. Soc.* Vol. 8, No. 20, p. 104.

standard deviation  $9.9^{\circ}$  F. Thus there are large fluctuations in the difference, and in fact it is often warmer over Reykjavik than over Duxford. The difference maintained a high average when a series of depressions moved over or to southward of Iceland, and for the period November 1st to February 9th the average was as high as  $26.5^{\circ}$  F. The extremes were  $44^{\circ}$  F. on February 4th and  $40^{\circ}$  F. on February 1st, and it can readily be seen from the charts that the air masses at the two stations were of widely different origin. (At a fixed pressure of 600 mb., the two extreme differences were  $41^{\circ}$  F. and  $36^{\circ}$  F.). The largest summer difference at 4 Km. was  $29^{\circ}$  F. on August 28th. The mean difference for July and August was  $12.2^{\circ}$  F., compared with only  $3.4^{\circ}$  F. for the period from April 15th to June 30th.

Temperature at 4 Km. was higher at Reykjavik than at Duxford on 22 out of 127 cases, or 17 per cent. On 19 occasions pressure at 4 Km. was higher at Reykjavik, and in another four cases it was the same to the nearest 1 mb. In 20 cases out of these 23 cases temperature at 4 Km. was higher at Reykjavik, so that pressure at 8 or 9 Km. was probably higher (or at least as high) over Reykjavik. A higher pressure over Iceland might involve either northerly or easterly upper winds between Iceland and England. Nephoscope observations of high or medium clouds in the British Isles north of Duxford showed north-east or east upper currents on nine of the occasions under consideration, and on another three occasions when there were no nephoscope observations, the upper current probably had an east component. Thus it is probable that the normal westerly upper current is reversed over a wide range of latitude on not much less than 10 per cent. of all days. At single stations in the British Isles the percentage of easterly upper currents is somewhat larger. It should be remembered that we are dealing with a region where the normal temperature gradient is below the average for the latitude.

Two cases of temperature reversals may be considered in greater detail. On February 9th temperature at 5 Km. was  $33^{\circ}$  F. lower at Reykjavik than at Duxford. By next day an incursion of polar air had caused a large fall of temperature over Duxford, while at Reykjavik there had been an equally large rise in the rear of a wedge of high pressure, so that temperature at 5 Km. was  $7^{\circ}$  F. higher than over Duxford. (3 and 4 Km. readings missing, but as the  $2\frac{1}{2}$  Km. reading is also higher over Reykjavik, there is no doubt as to the reality of the change).

The other example is of special interest in view of the great snowstorm over the British Isles on February 23rd-24th, 1933. On February 21st temperature at 4 Km. was  $1^{\circ}$  F. higher at Reykjavik, and on February 23rd it was no less than  $21^{\circ}$  F. higher, and pressure was 13 mb. higher. At Duxford at 13h. 30m. tempera-

ture was  $-20.5^{\circ}$  F. at 4 Km., an abnormally low reading. From surface conditions it is clear that the isotherms and isobars in the upper air must have been orientated more or less north to south, and that the gradients must have been steep where the depression formed off west Ireland. By 7h. on the 24th pressure was down to 986 mb. at Pembroke, and a cold air mass was quickly sweeping round the west side of the centre. Pressure and temperature at Reykjavik at 4 Km. were even higher than on the previous day, and it is obvious that the powerful easterly current on the north side of the depression must have extended to high levels. The sea-level gradient wind (*i.e.*, the approximate wind at 2,000 feet) was distinctly stronger on the north side of the depression than on the south side, and the slow westward drift of the depression after occlusion may be attributed to this fact, and to the fact that the easterly current was not merely superficial. Occluded depressions normally behave like vortices in a general current (when there is a general current), and drift slowly in the direction of their strongest winds, especially depressions intense enough to produce a fairly uniform temperature in their interior regions. The fact that the depression on February 24th moved westward instead of moving up the Channel or over southern England was of immense importance to British weather.

During the periods when pressure at 4 Km. over Reykjavik was as high as or higher than over Duxford, there was a complete absence of depressions moving east or north-east between the two stations. As a rule this was obvious beforehand from surface conditions, but nevertheless there is no doubt that upper air observations from Iceland would be very useful for forecasting on some occasions. A network of stations would be required for any large advance.

C. K. M. DOUGLAS.

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### Discussions at the Meteorological Office

The subject for discussion for the next meeting will be:—

January 15th, 1934.—*Observation of temperature in climatology (instruments, methods).* By L. Besson (Paris, A. Inst. Hydr. Climat., 7, 1932, Fasc. 4, No. 26) (in French). *Opener.*—E. V. Newnham, B.Sc.

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### Royal Meteorological Society

The opening meeting of this Society for the present session was held on Wednesday, November 15th, at 49, Cromwell Road, South Kensington, Prof. S. Chapman, F.R.S., President, in the Chair.

Preceding the Ordinary Meeting a Special General Meeting

was held, and revisions of the by-laws were adopted whereby the annual subscription became two guineas instead of three guineas, which amount had been payable since 1921. The compounding fees for Life Fellowship were also reduced.

The Council of the Royal Meteorological Society has awarded the Symons Gold Medal for 1934 to Sir Gilbert T. Walker, C.S.I., F.R.S. The medal is awarded biennially for distinguished work in connexion with meteorological science, and will be presented at the Annual General Meeting of the Society on January 17th, 1934.

At the Ordinary Meeting Mr. C. J. P. Cave showed a few lantern slides of photographs of clouds taken during the past summer; Sir Gilbert Walker, F.R.S., also exhibited lantern slides giving further evidence of the existence of cells.

*J. Edmund Clark, I. D. Margary and C. J. P. Cave.—Report on the Phenological Observations in the British Isles, December, 1931, to November, 1932.*

Exceptional warmth again prevailed until February, which was also excessively dry. But the year was most notable for its wetness and dullness, above all, April, May and July. These gave half as much rain again as usual and only three-quarters of the sunshine average. June and early autumn largely saved the situation for field and garden crops, and gave a fine floral display from August on.

Plant events after April to early July, were late by ten days or more in England and Wales, but a bare week for the British Isles as a whole, since Scotland and Ireland fared much better. Worst were England south-east, south-west and Midlands. The floral isokairs (equal divergences from the average) show this well, with areas in the former over a fortnight late for all plants against ten days early in the latter.

Scarcity and lateness of three butterflies were the response to the wet cold of late April and May. The same cause accounted for no bird in the main migrant table being early. Due presumably to food shortage the 7 insect-feeders up to May 9th averaged 4 days later than the other 8 birds in the same period. The Spring migrant isophenes (equal appearance dates) lay much further south than usual, the reverse occurring in autumn, when the genial weather favoured lingering.

The additional notes received from many proved as usual of great value and form an important part of the letterpress.

Tables present the dates of the separate plants in each of the 11 districts, with averages for England and Wales and for the British Isles, also corresponding averages for 35 years, which are confirmed after 40 years. In an appendix are now tabulated the results decade by decade, with comparisons and ranges. These tables summarise a presentation of our results from an aspect not previously attempted.

V. V. Sohoni and M. M. Paranjpe.—*Fog and Relative Humidity in India.*

In this paper the authors showed that the association of fogs with unsaturated air was fairly common in India. Further, that although thick fogs are predominantly associated with relative humidities of over 90 per cent., thin fogs are equally prevalent with humidities of from 90 to 70 per cent.

## Correspondence

To the Editor, *The Meteorological Magazine.*

### Where is the Rainbow?

The elementary theory of the rainbow explains how the phenomenon is produced by reflection and refraction of the sun's rays falling on raindrops, and that the bright coloured arch that we see is actually a multitude of drops which are momentarily in the right position to transmit the refracted and reflected light into the eyes of the observer. This is all quite simple and straightforward, but if we pursue the matter a little further we arrive at a curious and paradoxical result.

Suppose we attempt to locate the position of the rainbow in space by using one of the ordinary methods depending on parallax. We might, for example, use a range-finder, or take the bearings of a point on the bow, e.g., the apex, from two points at the ends of a measured base line. If that be done, the distance so determined is not the distance of the raindrops but "infinity," for the simple reason that it is impossible to observe the same rainbow from two different positions. When the observer moves from one position to the other, the rainbow moves too. The bearings measured from the two ends of the base line will be identical. It does not matter whether the bow is formed by a shower a mile away or by the spray from a garden hose-pipe a few yards away, the result must always be the same.

Now our own normal optical equipment consists of a pair of eyes which enable us to judge distances and to see things in their proper spatial relationship by observing simultaneously from two view points, about two and a-half inches apart. Speaking for myself, I feel positive that when I look at a rainbow formed by the spray of a garden hose, I judge it to be close at hand among the falling drops. The theory given in the preceding paragraph indicates, however, that I should judge it to be far behind the drops, at an infinite distance (or to be more accurate, at the distance of the sun). Possibly the explanation is that the parallax due to binocular vision is only one of the factors entering into our judgment of distance, other factors being brightness, contrast and apparent relative position. In the case of the rainbow the eyes see a bright translucent object

associated with the water drops, and interfering with the visibility of objects beyond the spray. The illusory evidence arising from binocular vision is rejected and the brain judges the bow to be where it really is—among the water drops.

Has anyone ever taken a stereoscopic photograph of the rain-bow formed in spray a few yards from the camera? It would be very interesting to see what it looks like in the stereoscope.

E. G. BILHAM.

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### The Hot Summer and the Scottish Snowbeds

Since my note in your last issue I have ascertained beyond any doubt that the snowbed in the Observatory Gully of Ben Nevis had also completely disappeared by September 23rd last. This information was furnished, among others, by five Scottish climbers who were climbing from the Hut at the foot of the Observatory Gully from September 23rd-25th.

The snowbed under Aonach Beag also disappeared on or about September 30th, so that for a week or ten days there could not have been any snow in all Scotland for the first time in memory, unless, which seems improbable, there is some undiscovered cleft in which snow accumulates in still greater depth than it does under (1) Ben Nevis, (2) Aonach Beag, and (3) Braeriach of the Cairngorms.

R. P. DANFORTH.

*Kentchurch Rectory, Hereford. November 28th, 1933.*

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### The Summer of 1933

While acknowledging the abundant sunshine of the past summer here in Lancashire at least the rainfall compares unfavourably with that of 1932; there were bad storms in June, especially on the 20th, and the rainfall in August was also greater than last year. The total rainfall (June to August inclusive) this year 8.35 inches was approximately 2 inches more than in 1932 which, in spite of the wet July was a really dry summer.

H. NOWELL, FEARINGTON.

*Worden Hall, Leyland, Lancashire. November 20th, 1933.*

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### A Brilliant Lunar Corona and Rain from an Apparently Cloudless Sky

The following phenomena were observed at this station on October 31st and November 5th respectively, and I send details in the hope that they may be of interest.

At 21h. 54m. G.M.T. on October 31st a very fine and beautifully coloured lunar corona was observed here. The sequence of colours when first observed was reddish-brown (on outside of ring), green, and blue (inside). At 22h. no less than three



distinct rings could be seen, the colour sequence now being reddish-brown (outside), green (very distinct), blue, reddish-brown, green, red, and finally whitish nearest the moon. After 22h. the corona quickly faded. The cloud in which it was seen was alto-cumulus with patches of smooth alto-stratus and was moving rapidly from north-west by north.

On November 5th at 8h. 35m. G.M.T., a few small drops of rain were observed to be falling from an apparently cloudless sky overhead. There was only  $\frac{3}{10}$ ths of cloud which consisted of a little cirro-stratus to the north-west with cirrus and cirro-cumulus, strato-cumulus and cumulus low down on the south and south-east horizons. The greatest amount of cloud was situated to the north. No cloud occurred in the zenith and very little above about a quarter of the whole sky. All three types of cloud were moving from some point of north-east, the cirriform cloud having a more northerly drift than the two lower types. The sun was shining strongly at the time but no rainbow was seen. The surface wind was northerly, moderate and the screen temperature was  $39^{\circ}$ . No rain was seen to be falling from the patches of strato-cumulus. About 11h. a very slight shower of drizzle occurred, but by this time the cloud had increased and had become more or less cumuliform. Only on one other occasion have I observed rain to fall from an apparently cloudless sky during the past six years.

A. E. MOON.

89, Clive Avenue, Clive Vale, Hastings. November 6th, 1933.

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### Sunspots and Sunshine

I am much obliged to Mr. Hawke for his contribution in your November issue, to the serious discussion of my article on the above subject. I gather from his own article that there is support for the  $3\frac{1}{2}$ - to 4-year periodicity in the occurrence of fine summers, which it was the main purpose of my own article in your October issue to prove, but that he disagrees with my statement that the exceptionally fine summers occur at the times of minimum sunspot activity. My statement and figures on this point were based upon an article which was published in the *Daily Mail* under his signature, on June 6th of the present year, in which he stated "that as far back as reliable meteorological observations are known to extend, at least one notably fine and hot season has invariably marked the approach of each minimum of the sunspot cycle. . . . Last winter there was a rather surprising rerudescence of solar activity for a couple of months, but this subsided during the spring and there can be little doubt that the minimum of a cycle associated in its approach with the

maximum tendency towards dry summer weather in this country is now at hand."

I am quite open to correction, however, on the point that the years of minimum sunspot activity are not exactly coincident with the years of maximum sunshine in this country, and to accept Mr. Hawke's figures of 1901, 1913 and 1923 as the correct years of sunspot minima during the present century. Only ten years separated, however, the last two periods of minimum, and it is still possible that 1933 may prove to be another year of minimum solar activity, as indicated by Mr. Hawke in the last paragraph quoted above.

JOHN B. C. KERSHAW.

*Oaklands, Conway Road, Colwyn Bay. November 25th, 1933.*

### Pollen in a Cloud

Recently, whilst flying over the Tochi Valley in Waziristan (with the object of taking dry and wet bulb temperature readings in and near cumulus cloud), my pilot and I had a rather unpleasant but interesting experience.

We entered a patch of cumulus, which was about 100 ft. thick, at approximately 3,900 ft. above the ground, the time being 10h. 30m. I.S.T. Immediately, I noticed a smell of hay and felt a tickling sensation in my nose. My eyes began to water, and I sneezed frequently until we emerged from the cloud. On landing shortly afterwards I saw that my pilot had also been affected. His eyes and nose were still in a lachrymose condition! He, too, stated that he could "smell" the cloud.

We had both observed that on the hillside below the patch of cumulus there was a party of villagers busily winnowing, and there appears to be little doubt that fine particles of chaff and pollen had been lifted into the cloud by convection currents. We did not experience any bumpiness just below the cloud, but from 3,000 ft. down to the ground the air was very turbulent.

The dry and wet bulb readings taken on the way down from 6,000 ft. were as follows:—

<i>Height.</i>	<i>Dry.</i>	<i>Wet.</i>
Ground level	91	80
1,000 ft.	84	74
2,000 "	78	69
3,000 "	72	64
4,000 "	66	61
5,000 "	65	58
6,000 "	61	54

It will be observed that the lapse-rate was super-adiabatic from ground-level to 3,000 ft., hence the ascending currents and consequent turbulence. The temperature readings just below, in, and outside the cloud have not been given, as they will be included in a set of similar observations to be published

at a later date. I may add that I, personally, am subject to catarrh, but that my pilot had never experienced "hay-fever" before!

R. G. VERRARD.

No. 1 (Indian) Group Headquarters, R.A.F., Peshawar. October 21st, 1933.

### Degree of Accuracy in Estimating Tenths

Using my wet and dry bulb observations for May, 1932, to October, 1933, I calculated the percentage frequency with which each of the figures 0 to 9 occurred in the decimal place. These are as follows:—

Figure	0	1	2	3	4	5	6	7	8	9
Percentage	28.5	12.2	11.8	6.8	4.8	2.7	5.5	0.9	10.8	11.0
Frequency	38.7	8.1	14.0	5.8	2.1	3.7	3.9	5.8	13.3	9.9

These figures, together with those of Dr. D. N. HARRISON\* seem to indicate that the ordinary observer is inclined to under-estimate the decimal place, if the value is less than  $\frac{1}{2}$  and to overestimate, if greater than  $\frac{1}{2}$ .

It seems to me that if observers calculated the percentage frequency from their own observations, as done above, they would then be able to make better estimates of the decimal places in their future observations, as they would then know where their errors lay.

R. H. DAW.

Treviso. St. Mary's Avenue, Northwood, Middlesex. November 6th, 1933.

Referring to the note on this subject in the *Meteorological Magazine* for October, surely the writer would not suggest that the figures quoted in his paragraph (2) are any criterion of what can be accomplished with a millimetre scale estimating to tenths.

The following are from Lerwick Tabulations (3,124 readings). No special virtue is claimed for them, the readings having been made in the ordinary course of the day's work. They are again hourly values as in Dr. Harrison's example:—

Figure	0	1	2	3	4	5	6	7	8	9
Percentage Frequency	8	8½	8½	10½	12½	10	18½	11	0½	9

The tendency seems to have been to over-estimate values below .5 and under-estimate those above .5. This is in contradiction to the Japan figures.† The partiality for sixes, however may be a human failing. Was it not suggested by the Japan experiment, where ".66 was a much greater stumbling block than .24"?

Objection might be made to the choice of these Lerwick figures for this purpose, on the grounds that they represent readings

\* See *Meteorological Magazine*, 68, 1933, p. 213.

† See *Meteorological Magazine*, 68, 1933, p. 191.

made by one individual and checked by a second. They may, however, be defended as follows:—

- (a) Reader and checker seldom differed by more than .1, in which case the reader's figure was unaltered.
- (b) Occasionally differences of .2 occurred, in which event the difference was divided. In these cases it is not too much to assume that the final figure was *in general* more nearly correct than the reader's.
- (c) Very occasionally differences of .3 or more occurred, but they invariably yielded to arbitration.

The net result would be that the reader's preferences as exhibited in (a) would be but slightly smoothed in the final result by the few cases occurring in (b).

Any favouritism which shows up in the final result, however, is not necessarily present in the reader alone. The checker might have similar tastes. That such a similarity does occur is shown by the following table covering another 3,308 observations, where the readings were made by one of three tabulators in turn, and checked by a second. There is a distinct similarity between this and the previous table:—

Figure	0	1	2	3	4	5	6	7	8	9
Percentage frequency	10½	7½	9	9½	11	10½	13	11	9½	8

This similar favouritism may be the function of the trace and may depend on its quality and on its thickness relative to the divisions on the scale.

Returning to the example quoted by Dr. Harrison, the suggestion of reading to the nearest half-millimetre would not have availed much. Presumably the tabulator would still have concentrated on the whole number, making 82 per cent. of readings end in 0.0 in the first case and 83 per cent. in the second.

J. C. CUMMING.

Lerwick Observatory. November 6th, 1933.

## NOTES AND QUERIES

### The "Gustiness" Shown on Pressure Tube Anemograms with Half-inch and One-inch Pressure and Suction Pipes

In May, 1930, the Dines anemograph with ½-inch pressure and suction pipes at Lympno was replaced by one having 1-inch pipes, and it was immediately noticed that the character of the records had changed, in that the trace showed not only a very much increased range of gustiness, but occasional notably low lulls. Accordingly, it was thought worth while by Mr. R. A. Watson, the officer in charge, to extract the figures given in Tables I and II below with a view to obtaining a quantitative value of the change of gustiness.

A measure of the gustiness was obtained as follows: The hour with the highest mean wind was taken out each day and the

highest gust and lowest lull in the hour noted. The mean value of these highest gusts divided by the mean wind in the hours in which they occurred was then deduced as a measure of the magnitude of the gusts. This is given under A in the tables below. Similarly, the mean of the lulls divided by the mean wind is given under B.

TABLE I.—Lympe, Anemograph with  $\frac{1}{2}$ -inch pipes.

1929.	A.	B.
January ... ..	1.39	.62
February ... ..	1.39	.66
March ... ..	1.31	.63
April ... ..	1.39	.61
May ... ..	1.38	.57
June ... ..	1.42	.52
July ... ..	1.48	.55
August ... ..	1.41	.54
September ... ..	1.38	.58
October ... ..	1.49	.53
November ... ..	1.45	.56
December ... ..	1.48	.57
Mean ... ..	1.41	.58

TABLE II.—Lympe, Anemograph with 1-inch pipes.

1930.	A.	B.
June ... ..	1.54	.25
July ... ..	1.69	.19
August ... ..	1.65	.26
September ... ..	1.60	.30
October ... ..	1.69	.17
Mean ... ..	1.63	.23

The very marked effect of the change from  $\frac{1}{2}$ -inch to 1-inch pipes on the lulls is at once noticeable from these figures.

In order to ascertain to what extent the lulls at Lympe were abnormal, similar figures were then got out in the Meteorological Office for other stations, particularly those where anemometers with  $\frac{1}{2}$ -inch pipes had been replaced by instruments with 1-inch pipes. The results are shown in Table III. The length of connecting pipes is about 30-35 feet in all cases except at Croydon and Lympe, where the pipes are 70 feet in length. The length is of some importance as the damping effect of long pipes will be more marked than that of short pipes, particularly in the case of  $\frac{1}{2}$ -inch pipes.

Table III shows, as would be expected, that the substitution of 1-inch connecting pipes for  $\frac{1}{2}$ -inch pipes leads in all

cases to an increase in the gustiness of the record, the gusts being raised and the lulls lowered. It also shows that while at

TABLE III.

<i>Station.</i>	<i>Diameter of Pipes.</i>	<i>A.</i>	<i>B.</i>
Science Museum, London, S.W.7.	1 inch	2.39	.013
Croydon ... ..	1 "	1.67	.42
Lympne ... ..	1 "	1.63	.23
Lympne ... ..	$\frac{1}{2}$ "	1.41	.58
Pendennis ... ..	1 "	1.48	.52
Pendennis ... ..	$\frac{1}{2}$ "	1.35	.63
Scilly (Telegraph) ...	1 "	1.42	.58
Scilly (Garrison) ...	$\frac{1}{2}$ "	1.34	.65
Holyhead ... ..	1 "	1.52	.53
Holyhead ... ..	$\frac{1}{2}$ "	1.34	.62
Bell Rock ... ..	1 "	1.28	.70
Lerwick ... ..	1 "	1.47	.58
Lerwick ... ..	$\frac{1}{2}$ "	1.37	.68

Lympne the effect on the gusts was not dissimilar to that at other stations, the effect on the lulls was decidedly abnormal. This is brought out even more clearly in the following table where the ratios of  $A_1$  to  $A_{\frac{1}{2}}$  and of  $B_1$  to  $B_{\frac{1}{2}}$  are set out. The suffixes refer to the diameter of the pipes.

TABLE IV.

	$\frac{A_1}{A_{\frac{1}{2}}}$	$\frac{B_1}{B_{\frac{1}{2}}}$
Scilly ... ..	1.06	0.89
Lerwick ... ..	1.07	0.85
Pendennis ... ..	1.10	0.83
Holyhead ... ..	1.13	0.85
Lympne ... ..	1.16	0.40

The fact that the connecting pipes are of greater length at Lympne than at the other stations in this table would readily explain the slightly larger figure 1.16 for gusts. It would not however be sufficient to account for the abnormally low figure for the lulls. The figure 0.40 for the ratio  $B_1$  to  $B_{\frac{1}{2}}$  at Lympne seems to be indicative of some peculiar system of eddies which give marked lulls of such short period that they are to a very considerable extent damped out on the records of a pressure tube recorder with  $\frac{1}{2}$ -inch pipes though they are recorded satisfactorily on one with 1-inch pipes.

Turning again to Table III, in general the difference between A and B is less at the coastal stations than at the inland stations and this difference forms a measure of the turbulence of the wind. Placing the stations in order of increasing turbulence, we obtain Table V. The figures relate to anemometers fitted with

1-inch pipes in each case. The exceptional turbulence recorded

TABLE V.

					Difference A—B.
Bell Rock	...	...	...	...	0.58
Scilly	...	...	...	...	0.84
Lerwick	...	...	...	...	0.89
Pendennis	...	...	...	...	0.96
Holyhead	...	...	...	...	0.99
Croydon	...	...	...	...	1.25
Lympne	...	...	...	...	1.40
Science Museum, London, S.W.7	...	...	...	...	2.26

by the anemometer on the roof of the Science Museum in the heart of London is well shown.

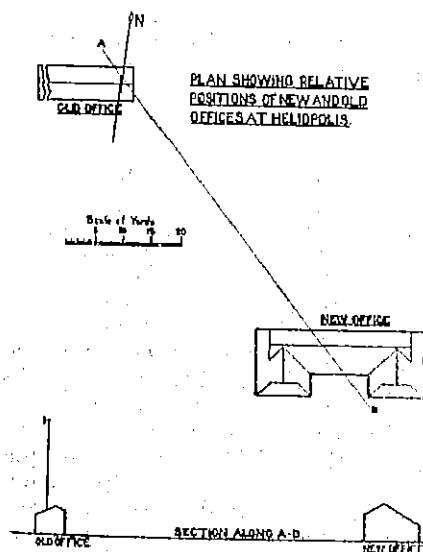
J. S. DINHS.

### The Effect of a Building on the Gustiness of the Wind

The meteorological station at Heliopolis, north-east of Cairo, lies in fairly level country with a general slope from south to north, bounded between south-east and south-west by comparatively

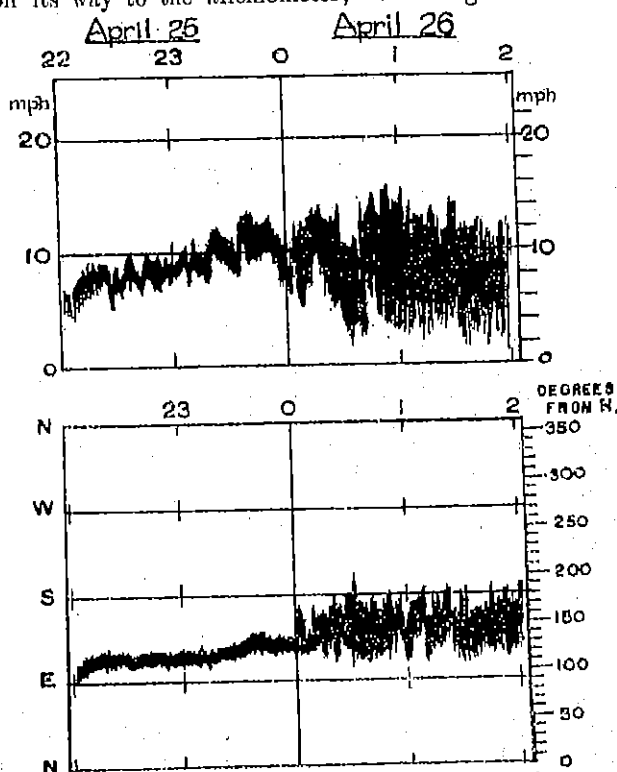
high ground, which rises to 1,000 feet at a distance of 12 miles to the south-east. This high ground causes a well-defined katabatic wind from a south-easterly direction on many nights.

Winds are measured by a pressure-tube anemometer erected above the old Meteorological Office building, 26 feet above the apex of the roof and 40 feet above the ground. Mr. J. Durward remarks that before the erection of the new office, the katabatic winds from between E. and S. all showed very little gustiness.



The new office building (see Fig. 1) is to the south-east of the anemometer mast. The furthest corner is 180 feet distant and the nearest corner about 135 feet. The height of the new building is 14 feet to the eaves, about 19 feet to the apex of the roof,

and its length is 88 feet. Fig. 2, representing a portion of the anemometer trace at Heliopolis on April 25th and 26th, 1933, shows the effect of the introduction of this building. During the first part of the trace, the wind did not pass over the new building on its way to the anemometer, and the gustiness is small,



the "factor of gustiness" (ratio of the width of the trace to the mean velocity) being only about 0.6 or 0.7. After the wind veered beyond about  $130^\circ$  however, so that the new building lay in the path of the wind to the anemometer, the width of the trace became very much greater and the factor of gustiness increased to about 2.0, while the mean wind speed was reduced by 1-2 miles per hour. This trace is of considerable interest in connexion with the problem of anemometer exposure.

### Books Received

*Deutsches Meteorologisches Jahrbuch*, 1931. Freie Hansestadt Bremen. Edited by Dr. A. Mey. Jahrgang 42, Bremen, 1932. In addition to the usual very complete presentation of this



year's data, this volume contains two interesting notes, one on "A comparison of temperature within and without the town of Bremen," by A. Mey, and the other on "A contribution to the Climatology of the North Sea coast," by P. Lühe and W. Feld. *The electric field of overhead thunderclouds.* By S. K. Banerji, D.Sc. London: Phil. Trans. Roy. Soc., series A, vol. 231, pp. 1-27.

### Obituary

LUIGI PALAZZO, *Socio nazionale della Reale Accademia Nazionale dei Lincei Grand' Ufficiale della Corona d'Italia, Commendatore della Corona di Prussia, e dell'Aquila Rossa.*—On June 13th of this year Luigi Palazzo died in Florence; his wife, Maria Giuseppina, after a union of forty-four years, had previously died in Rome on April 9th, to the great grief of himself and his family.

Palazzo had been associated with the meteorological and geophysical service of Italy for forty-three years and director for thirty-one of them. He had retired from the directorate of the Office in the Collegio Romano, on reaching the age limit, on October 31st, 1931. His services were forthwith commemorated by the *Premio Palazzo*, a prize founded by subscription to be awarded every four years by the Accademia dei Regi Lincei for contributions to meteorology or geophysics within the eight years previous to the award.

Palazzo's career is set out by Professor G. B. Rizzo of Naples in the July-August number of *Meteorologia Pratica*, the organ of the Società Meteorologica Italiana, of which Palazzo was for many years vice-president. He was also President of the International Seismological Association and Vice-President of the Italian Committee for Geodesy and Geophysics, and held many other appointments and distinctions. A list of papers includes 8 on experimental physics with hygiene, 40 on meteorology and aerology, 61 on terrestrial magnetism, 13 on seismology, 34 biographical notices, addresses or books.

The development of the Government service with which he was so long associated is set out by P. D. Bernardo M. Paoloni, O.S.B., in the correspondence number of the same journal in 1931.

He was born in Turin on January 18th, 1861, was at school at the Liceo "Cavour" in that city, and entered the University in November, 1880, graduated in physics in July, 1884, with a special taste for experiment, spent two years at Rome in the Ufficio Centrale di Meteorologia and in the Istituto Fisico dell' Università there, devoting himself mainly to terrestrial magnetism. Then two years in German universities, first at Würzburg and then at Berlin and the Prussian Meteorological Institute, again with special devotion to terrestrial magnetism.

In 1887 he was called to succeed Chistoni as Physical Assistant in the Ufficio Centrale at Rome, and from that time was in charge of terrestrial magnetism for Italy, a branch of science which he developed with scrupulous care and attention throughout his life. His magnetic charts of Italy and her colonies are a permanent memorial.

In September, 1899, when Prof. Tacchini retired from the direction of the Italian Office, Palazzo was nominated *Reggente la Direzione dell'Ufficio*, and in August, 1901, Director. So the responsibility for meteorology was included in his *carica* with that for magnetism.

In 1900 in the midst of a very embarrassing political situation he and I were present together at an open meteorological conference at Paris in connexion with the International Exhibition of that year. On September 15th at the end of the Conference in a small room at the top of the Eiffel Tower an irregular meeting of the International Meteorological Committee was held under the Chairmanship of E. Mascart, Director of the Bureau Central Météorologique, Professor of Physics in the Collège de France, and afterwards President of the Academy of Sciences. At that meeting Palazzo and I were elected members of the Committee in succession to Ciro Tacchini and Robert Henry Scott, and thereafter I had many opportunities of renewing our friendship, including two visits to Rome on my part and at least two visits to England on his.

As a member of the Committee and of many of the special commissions he was a regular attendant at the international meetings. German was ordinarily his second language, and terrestrial magnetism was evidently his own subject; but he missed no opportunity of meteorological investigation and combined it with his visits of magnetic exploration, as in his expedition to Zanzibar in July, 1908, and to the Indian Ocean with *ballons-sondes* for use at sea in December, 1909.

He was in every way a "good companion," and like many good companions he developed a deafness which interfered to some extent with social amenities. When an international commission, meeting in London, went to spend a week-end at Ditcham Park with Mr. Cave, he was discovered on the platform at the station with no luggage, not having heard the whole of the invitation; but he got there all right as usual, and at dinner he astonished ladies on either side of him, specially invited to talk to him in Italian, by responding to their carefully elaborated Italian in French. However, the chief feature of that notable assembly was the consternation when one of the guests, who had never shaved himself, found himself five miles away from the nearest tonsorial artist. That was not Palazzo; he wore a beard.

Palazzo continued as a member of the International Committee

until the month of his retirement from Office, and on October 5th, 1931, he attended the meeting at Locarno and took affectionate farewell with many friendly reminiscences of what certainly could claim to be the most fraternal assembly in the world of the representatives of diverse nationalities.

NAPIER SHAW.

### News in Brief

The 1934 annual meeting of the British Association will be held at Aberdeen from September 5th to 12th under the presidency of Sir William Hardy, F.R.S. Col. Sir Henry Lyons, F.R.S., has been appointed President of the Conference of Delegates of Corresponding Societies.

At the anniversary meeting of the Royal Society on November 30th, 1933, the Royal Medal, 1933, was presented to Prof. G. I. Taylor for wide researches including among other subjects turbulence and the formation of fog, and the Hughes Medal, 1933, to Prof. E. V. Appleton for researches on the ionosphere.

The Buys Ballot Medal, 1933, has been awarded by the Koninklijk Akademie van Wetenschappen to Amsterdam to Prof. V. Bjerknes. The medal is awarded every ten years, the recipient in 1923 being Sir Napier Shaw.

We learn from *Nature* that the Oxford Congregation has voted an additional grant of £50 to the School of Rural Economy for an expedition to a district of the southern Sudan with the view of investigating extreme conditions of drought and rainfall in their bearing on agricultural development.

Admiral Byrd is on his way to the Bay of Whales in the Antarctic with a surveying expedition of two ships, one of which carries an aeroplane and an autogyro. The expedition hopes to reach Admiral Byrd's former encampment on Christmas Day. The collection of meteorological observations is one of the objects of the expedition.

### Errata

October, 1933, p. 213, last line but one, for "ended in 0.9, 0.0 or 0.1" read "ended in '9, '0 or '1," and p. 214, line 4, for "end in 0.0 or 0.5" read "end in '0 or '5."  
 November, 1933, p. 240, last line but one, after "By Charles H. Brown," add "7th edition. Size 8½ in. x 5½ in., pp. ix + 234. *Illus.* Glasgow: Brown, Son & Ferguson Ltd., 1933, 7s. 6d. net."

## The Weather of November, 1933

Pressure was above normal over western North America, Spitsbergen, Iceland, northern Europe and eastern North Atlantic, the greatest excesses being 7.7 mb. at 50° N. 120° W. and 7.5 mb. at Lerwick. Pressure was below normal over most of eastern North America, western North Atlantic and central and southern Europe and the Mediterranean, the greatest deficits being 6.2 mb. at Zurich and 4.8 mb. at 60° N. 60° W. Temperature was above normal at Spitsbergen and northern Norway, but below normal generally elsewhere in western Europe. Rainfall was in excess in the north but deficient in central Europe and most of Sweden; in north-west Gothaland there was only 10 per cent. of the normal.

The chief feature of the weather of November over the British Isles was the deficiency of rain except along the east coast. At Ross-on-Wye and Stornoway the monthly totals were only 22 per cent. and 30 per cent. of the normal, while at Tyne-mouth, the total of 4.41 in. was more than twice the normal. Sunshine was generally above the normal in the western districts and the mean temperature mainly below normal in the south but above normal in the north. There was a marked absence of south-westerly winds. Squally winds from NW. veering N. persisted generally until the 3rd, in the rear of a depression moving east over the North Sea and reached gale force locally, while the weather was showery with snow on the hills in Scotland and hail at a few places, even in the south. Sunshine records were good during this time, over 8 hrs. at several places. After the 3rd an anticyclone spread in from the Atlantic, mainly fair to cloudy weather with slight showers prevailed and the winds moderated though continuing from the north. The air, however, was coming from the south round the anticyclone and on the 6th gave high temperature in the north, when 62° F. was recorded at Leuchars and 61° F. at Dundee, and on the 7th in the south as well. Much mist and fog prevailed from the 5th to 9th. On the 8th the winds backed to W. and SW. and the weather again became cold and unsettled though with sunny intervals. The 11th was a markedly cold day generally, at Renfrew the maximum temperature did not rise above 37° F. On the 14th a depression passed south-south-east across the country giving strong winds or gales at times in Scotland and Ireland and heavy rain locally, 1.75 in. fell at Donaghadee (Co. Down), and 1.60 in. at Borrowdale (Cumberland) on the 14th and 1.04 in. at Talylyn (Merioneth) on the 15th. From then until the 18th the winds were easterly and the weather cloudy with scattered showers, but after the 18th the winds veered to SE. and S. and the temperature rose. During the following brief mild spell a maximum of 60° F. was recorded at Croydon

on the 20th and conditions were generally quiet with much fog over most of England until the 23rd, though brighter weather occurred in the west and north. On the 24th the winds freshened somewhat from NE. or N. causing a drop in temperature as the anticyclone to the north spread over the country. Showers of sleet and snow were experienced along the east coast on the 25th, while on the 26th persistent fog at Renfrew was associated with a maximum temperature of 26° F. The greater part of the country remained under the influence of this anticyclone until the end of the month, the weather being generally cold and dry with little sun and much mist or fog. Meanwhile a depression approached from the Atlantic on the 27th giving south-easterly winds with milder fairer weather along the western seaboard. This was maintained until the 30th when the winds in the north and west freshened from S. or SE. with gales locally, and heavy rain fell in south-west Ireland, 1.70 in. at Valentia, Co. Kerry. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	51	+ 8	Liverpool	56	— 4
Aberdeen	47	— 8	Ross-on-Wyo	71	+ 8
Dublin	50	—12	Palmouth	63	—13
Birr Castle	68	+ 4	Gorleston	44	—18
Valentia	80	+15	Kew	48	— 4

The special message from Brazil states that the rainfall was generally scarce with averages 0.12 in. above normal and 0.83 in. and 1.10 in. below normal in the northern, central and southern regions respectively. Five anticyclones crossed the country. The crops were generally in good condition except in the north-east where the cane was affected by the unfavourable weather and in the south on account of the locusts. At Rio de Janeiro the mean pressure was 0.4 mb. above normal and mean temperature 0.9° F. below normal.

*Miscellaneous notes on weather abroad culled from various sources*  
It was reported on the 6th that the snow in Switzerland was 1 ft. deep at the 3,600 ft. level and 6 ft. deep above the 6,000 ft. line, and on the 18th that snow had fallen in Turin and over Piedmont. On the 20th Stugsund was free of ice, but at most of the other ports in the Gulfs of Bothnia and Finland thin ice had formed though navigation was not hindered. Falls of from 12 in. to 18 in. of snow occurred on the 28th over most of Switzerland and snow fell during the 26th and 27th in Alsace, the fall being especially heavy in the Vosges. A severe storm occurred along the Turkish Black Sea coast at the end of the month and 17 people were drowned. (*The Times*, November 7th-December 2nd.)

On the 9th, it was recorded that the drought in South Africa had broken as good soaking rains had fallen in many districts of the Cape during the previous 48 hours, and also in scattered districts of south-west Africa. In the Free State, Transvaal and Natal rains had started a few days before that. Good rains also fell in Kenya during the week ending the 21st. A series of dust storms occurred in the Orange Free State towards the end of the month, culminating on the 29th in a storm which did much damage to the southern districts of Rouxville, Bethulie and Smithfield. (*The Times*, November 10th-December 1st.)

A severe hailstorm is reported on the 17th to have demolished the houses at Nanyang 27 miles from Hsipaw in the Shan States, Burma, killing three people and making 300 more homeless. The storm uprooted great trees and ruined the crops, the hailstones being of a large size unprecedented in the Shan States. (*The Times*, November 18th.)

On the 18th it was stated that useful rains varying from  $\frac{1}{2}$  in. to 1 in. had fallen over Victoria; on the 20th the severe drought in the north-eastern pastoral country of South Australia was broken, and after this, extensive and timely rains occurred over the whole State, amounting to as much as 3-5 in. in two days in some places. Towards the end of the month, however, serious floods followed torrential rains and large areas of wheat and other crops were damaged and three lives lost. The weather had moderated at the end of the month. (*The Times*, November 20th-December 2nd.)

Abnormally cold weather occurred in Ontario about the 16th. and a snowstorm was raging over the Great Lakes from the 9th to 16th. From the 21st navigation was difficult in the St. Lawrence River owing to the ice conditions. On the 28th close packed ice also occurred from Quebec to Murray Bay beyond which there was open water. Temperature in the eastern United States was above normal at the beginning of the month, but by the second week the cold spell in the west was extending also to the east. This was followed by a warm spell which extended south-east only at first and did not reach the north-eastern States until towards the close of the month. Precipitation was generally below normal. (*The Times*, November 16th-30th, and *Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin*.)

Severe gales were experienced at times on the North Atlantic.

### General Rainfall for November, 1933

England and Wales	...	50	} per cent of the average 1881-1916.
Scotland	...	67	
Ireland	...	49	
British Isles	...	<u>50</u>	

## Rainfall: November, 1933: England and Wales.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>London</i>	Camden Square .....	·88	39	<i>Leics.</i>	Thornton Reservoir ...	1·72	76
<i>Kent</i>	Tenterden, Ashenden...	1·48	49		Belvoir Castle .....	1·94	87
"	Folkestone, Boro. San.	2·16	...	<i>Rut.</i>	Ridlington .....	2·00	87
"	St. Peter's, Hildersham	...	...	<i>Lines</i>	Boston, Skirbeck .....	2·20	115
"	Eden'bdg., Falconhurst	1·01	28	"	Cranwell Aerodrome ...	2·15	115
"	Sevenoaks, Speldhurst	1·25	...	"	Skugness, Marine Gdns	1·94	90
<i>Sus.</i>	Compton, Compton Ho.	·90	24	"	Louth, Westgate .....	1·87	72
"	Patching Farm .....	1·28	35	"	Brigg, Wrayby St. ....	1·68	...
"	Eastbourne, Wil. Sq.	1·24	35	<i>Notts</i>	Worksop, Hudsock ...	1·93	98
"	Heathfield, Barklye ...	1·63	44	<i>Derby</i>	Derby, L. M. & S. Rly.	1·04	48
<i>Hants.</i>	Ventnor, Roy. Nat. Hos.	1·00	81	"	Buxton, Torr. Slopes	2·50	68
"	Fordingbridge, Oaklands	1·01	30	<i>Ches</i>	Runcorn, Weston Pt. ...	1·78	64
"	Ovington Rectory .....	·80	24	<i>Lancs.</i>	Manchester, Whit Pk.	1·14	43
"	Sherborne St. John ...	·46	16	"	Stonyhurst College ...	1·01	42
<i>Herts.</i>	Welwyn Garden City...	1·88	50	"	Southport, Hesketh Pk	1·56	50
<i>Bucks.</i>	Slough, Upton .....	·99	46	"	Lancaster, Greg Obay.	1·81	46
"	H. Wycombe, Flackwell	·92	45	<i>Yorks.</i>	Wath-upon-Deane ...	1·70	88
<i>Oxf.</i>	Oxford, Mag. College...	1·00	46	"	Wakefield, Clarence Pk.	2·04	96
<i>Nor.</i>	Pitsoford, Sedgemoor...	...	...	"	Oughtershaw Hall .....	4·33	...
"	Oundle .....	1·70	...	"	Wetherby, Ribston H.	3·15	135
<i>Bed.</i>	Woburn, Exptl. Farm...	1·52	68	"	Hull, Pearson Park ...	2·80	132
<i>Cam.</i>	Cambridge, Bot. Gdns.	1·25	65	"	Holme-on-Spalding ...	2·10	90
<i>Essex.</i>	Chelmsford, County Lab.	1·19	53	"	West Witton, Ivy Ho.	3·43	99
"	Lexden Hill House ...	1·08	...	"	Felixkirk, Mt. St. John	4·07	108
<i>Suff.</i>	Haughley House .....	1·48	...	"	York, Museum Gdns.	2·70	120
"	Campsea Ashc. ....	3·54	100	"	Pickering, Hungate ...	3·06	123
"	Lowestoft Sec. School	3·49	148	"	Scarborough .....	2·11	86
"	Bury St. Ed. Westley H.	1·71	74	"	Middlesbrough .....	3·24	153
<i>Norfol.</i>	Wells, Holkham Hall	2·07	96	"	Baldersdale, Hury Res.	2·70	78
<i>Wills.</i>	Dorchester, Highclere...	·78	27	<i>Durh.</i>	Ushaw College .....	4·40	178
"	Calne, Castleway .....	·67	27	<i>Nor.</i>	Newcastle, Town Moor	8·32	137
<i>Dor.</i>	Everashot, Melbury Ho.	1·07	25	"	Bellingham, Highgreen	2·69	78
"	Weymouth, Westham .	·68	22	"	Lilburn Tower Gdns...	4·46	133
"	Shaftesbury, Abbey Ho.	·69	21	<i>Cumb.</i>	Carlisle, Scalby Hall	·85	28
<i>Devon.</i>	Plymouth, The Hoe ...	1·50	41	"	Borrowdale, Seathwaite	3·00	23
"	Holne, Church Pk. Oct.	1·63	30	"	Borrowdale, Moraine...	8·72	30
"	Teignmouth, Den Gdns.	·90	31	"	Keswick, High Hill...	1·86	88
"	Ottilampton .....	·89	20	<i>West.</i>	Appleby, Castle Bank	1·99	60
"	Sidmouth, Sidmouth...	1·19	38	<i>Mon.</i>	Abergavenny, Larchfd	1·12	29
"	Barnstaple, N. Dev. Ath	1·33	34	<i>Glam.</i>	Ystalyfera, Wern Ho.	1·84	25
"	Dartm'r, Cranmere Pool	2·50	...	"	Cardiff, Ely P. Stn. ...	·98	22
"	Okehampton, Uplands	1·70	32	"	Treharbert, Tynywam	2·44	...
<i>Corn.</i>	Redruth, Trowrigie ...	2·18	45	<i>Carm.</i>	Carmarthen Friary ...	·80	16
"	Penzance, Morrab Gdn.	1·70	38	<i>Pemb.</i>	Haverfordwest, School	1·81	96
"	St. Austell, Trovarna...	2·17	44	<i>Card.</i>	Aberystwyth .....	1·02	...
<i>Soms.</i>	Chewton Mendip .....	·08	16	<i>Rad.</i>	Birm W.W. Tynywyydd	1·80	28
"	Long Ashton .....	·57	18	<i>Mont.</i>	Lake Vymwy .....	1·62	29
"	Street, Millfield .....	·68	25	<i>Flint.</i>	Sealand Aerodrome ...	1·37	57
<i>Glos.</i>	Blockley .....	1·38	...	<i>Mer.</i>	Dolgellay, Bontddu ...	2·13	35
"	Gloucester, Gwynfa ...	1·12	98	<i>Carm.</i>	Llandudno .....	1·41	49
<i>Here.</i>	Ross, Birehles .....	·07	26	"	Snowdon, L. Llydaw 9	5·19	...
<i>Salop.</i>	Church Stretton .....	·85	29	<i>Ang.</i>	Holyhead, Salt Island	1·81	44
"	Shifnal, Hatton Grange	1·17	45	"	Lligwy .....	2·25	...
<i>Staffs.</i>	Market Drayton, Old Sp.	1·82	50	<i>Isle of Man</i>			
<i>Worc.</i>	Ombersley, Holt Lk.	·77	34	"	Douglas, Boro' Cem. ...	2·40	50
<i>War.</i>	Alcester, Ragley Hall...	·96	42	<i>Guernsey</i>			
"	Birmingham, Edgbaston	·98	89	"	St. Peter P't. Grange Rd	8·22	77

## Rainfall: November, 1933: Scotland and Ireland.

Co.	STATION	In.	Per- cent of Av.	Co.	STATION	In.	Per- cent of Av.
Wig.	Pt. William, Monreith	2.40	58	Suth.	Melvich	2.06	74
"	New Luce School	3.22	03	"	Loch More, Aohfary	3.28	73
Kirk.	Dalry, Glendarroch	2.55	43	Caith.	Wick	2.94	94
"	Carsphairn, Shiel	3.53	46	Ork.	Doorness	2.79	71
Dumf.	Dumfries, Orichton, R.I.	2.04	50	Shet.	Lerwick	2.01	68
"	Esksdalemuir Obs.	2.07	30	Cork.	Caheragh Rectory	2.77	...
Roos.	Branksholm	1.69	51	"	Dunmanway Rectory	2.99	48
Selk.	Ettrick Manse	2.34	43	"	Cork, University Coll.	2.72	68
Peab.	West Linton	1.02	...	"	Ballinacorra	2.63	66
Berw.	Marchmont House	2.50	33	Kerry.	Valentia Obsy	3.07	67
E. Loth.	North Berwick Res.	1.44	04	"	Gearhamoon	4.70	48
Midd.	Edinburgh, Roy. Obs.	1.44	04	"	Darrynane Abbey	3.59	70
Lan.	Anchtysfardle	1.30	...	Wat.	Waterford, Gortmore	1.55	42
Ayr.	Kilnarnock, Kay Pk.	1.80	...	Tip.	Nenagh, Cas. Lough	1.12	28
"	Grvan, Plinmore	2.54	48	"	Roserea, Timoney Park	1.21	...
Renf.	Glasgow, Queen's Pk.	1.79	48	"	Cashol, Ballinamona	.81	23
"	Greenock, Prospect H.	3.35	52	Lim.	Foynes, Coolnaneas	1.81	33
Bute.	Rothsary, Ardenoraig	3.81	...	"	Castloconnel Res.	.91	...
"	Dougarie Lodge	2.80	...	Clare.	Inagh, Mount Callan	2.30	...
Arg.	Ardgour House	3.88	...	"	Broadford, Hurdlest'n	1.17	...
"	Glen Elvie	...	...	Wexf.	Gorey, Courtown Ho.	.79	23
"	Oban	2.51	...	Wick.	Rathnew, Oloannan	1.63	...
"	Poltalloch	4.08	72	Carl.	Hacketstown Rectory	1.84	47
"	Inveraray Castle	4.99	59	Letz.	Blandsfort House	2.10	63
"	Islay, Eallabus	3.13	58	"	Mountmellik	1.79	...
"	Mull, Bonmore	...	...	Offaly.	Birr Castle	1.16	37
"	Three	3.01	75	Dublin.	Dublin, FitzWin. Sq.	.90	36
Kins.	Loch Leven Sluice	1.58	44	"	Balbriggan, Ardgillan	1.35	47
Perth.	Loch Dhu	...	...	Meath.	Boaupare, St. Cloud	1.54	...
"	Balquhider, Stronvar	...	...	"	Kells, Headfort	2.10	62
"	Crieff, Strathearn Hyd.	2.00	67	W. M.	Moate, Coolatoro	1.43	...
"	Blair Castle Gardens	3.20	04	"	Mullingar, Belvedere	1.28	38
Angus.	Kottins School	3.00	97	Lony.	Castle Forbes Gdn.	1.27	36
"	Pearcie House	4.02	...	Gal.	Galway, Grammar Sch.	1.58	...
"	Montrose, Sunnyside	2.32	100	"	Ballynahinch Castle	3.04	51
Aber.	Braemar, Bank	3.85	100	"	Ahasragh, Olonbrook	1.95	48
"	Logie Coldstone Sch.	3.03	118	Mayo.	Blackscd Point	3.03	58
"	Abordon, King's Coll.	3.24	110	"	Mallaramy	3.41	...
"	Fyvie Castle	4.21	122	"	Westport House	2.37	48
Moray.	Gordon Castle	1.09	59	"	Dolphi Lodge	4.54	44
"	Grantown-on-Spy	...	...	Sligo.	Markree Obsy	2.53	60
Nairn.	Nairn	.87	37	Cavan.	Crossdonoy, Kevlt Cas.	1.04	...
Inver.	Ben Alder Lodge	2.10	...	Fern.	Kinniskillen, Portora	1.03	...
"	Kingussie, The Bitches	1.43	...	Arm.	Anagh Obay	.94	38
"	Inverness, Oldduthel R.	.50	...	Down.	Fofanny Reservoir	2.40	...
"	Loch Quoich, Loan	5.00	...	"	Seaforde	1.57	41
"	Glenquoich	3.50	29	"	Donaghadee, C. Stn.	3.11	102
"	Ardsaly, Fairo-na-Sguir	3.30	...	"	Banbridge, Milltown	1.08	39
"	Fort William, Glasdrum	3.42	...	Antr.	Belfast, Cavehill Rd.	1.42	...
"	Skye, Dunvegan	2.93	...	"	Aldergrove Aerodrome	1.60	49
"	Barra, Skallary	2.85	...	"	Ballymena, Harryville	2.48	61
R. & O.	Alnosa, Ardross Castle	3.80	82	Lon.	Garvagh, Moneydig	2.03	...
"	Ullapool	3.50	07	"	Londonderry, Oreggan	2.28	50
"	Achnashellach	4.89	54	Tyr.	Omagh, Edenfel	1.40	37
"	Stornoway	1.78	31	Don.	Malin Head	2.11	...
Suth.	Lairg	2.41	00	"	Millford, The Manse	2.38	55
"	Tongue	3.00	65	"	Killybegs, Rockmount	.98	...



## Climatological Table for the British Empire, June, 1933

STATIONS	PRESSURE		TEMPERATURE							Mean Cloud Am't	PRECIPITATION		BRIGHT SUNSHINE		
	Mean of Day M.S.L.	Diff. from Normal	Absolute		Mean Values						Am't in.	Diff. from Normal in.	Days	Hours per day	Per- cent. of age of day possible
			Max.	Min.	Max.	Min.	1 2 min.	Diff. and from Normal	Mean						
London, Kew Obsy.	1011.7	-5.0	85	45	70.9	52.7	61.8	+2.6	54.0	4.3	1.93	0.22	10	8.6	52
Gibraltar	1014.7	-2.6	87	57	80.3	61.4	70.9	+0.4	60.2	2.3	0.00	0.54	0	..	70
Malta	1013.3	-1.9	88	59	74.3	64.5	59.7	-3.0	63.6	7.3	0.50	0.41	5	10.9	..
St. Helena	1016.1	+0.3	65	54	62.4	56.5	59.5	-1.0	57.1	9.0	2.66	..	20	..	..
Freetown, Sierra Leone	1013.9	+1.9	89	68	85.1	72.0	78.5	-1.8	75.3	8.7	30.01	9.97	29	..	..
Lagos, Nigeria	1012.6	+0.2	86	71	83.4	75.0	79.2	-0.3	75.6	9.4	14.86	..	25	2.5	20
Kaduna, Nigeria	1013.5	-0.3	90	65	85.3	69.4	77.9	+1.4	72.1	8.3	6.65	0.44	17	6.5	51
Zomba, Nyasaland	1015.6	-1.9	90	50	76.8	55.2	66.0	+3.1	58.8	6.7	1.11	+0.68	5	..	..
Salisbury, Rhodesia	1019.5	-1.2	77	38	70.8	46.3	58.5	+1.6	51.5	6.1	0.19	+0.14	2	8.0	72
Cape Town	1018.6	-1.5	89	37	60.8	47.1	53.9	+1.8	47.9	9.2	4.71	0.21	16	..	..
Johannesburg	1021.7	-1.0	87	28	58.1	39.3	48.7	-2.0	39.4	5.0	0.21	+0.07	1	9.1	87
Mauritius	1018.8	-0.2	81	55	76.5	63.9	70.2	+0.8	67.1	7.4	2.93	+0.13	17	6.5	60
Calcutta, Alipore Obsy.	998.4	-1.3	97	75	91.0	79.5	85.3	+0.2	80.2	8.7	15.71	3.80	19*	..	..
Bombay	1003.8	-0.2	93	76	88.6	78.9	83.7	-0.3	78.6	8.3	7.4	10.29	..	..	..
Madras	1004.3	+0.5	102	75	98.8	81.6	90.2	+0.2	76.1	6.0	0.75	1.22	2*	..	..
C Colombo, Ceylon	1010.0	+1.4	86	72	84.7	76.5	80.6	-1.0	77.4	8.0	7.6	10.12	2.80	25	5.2
Singapore	1008.5	-0.1	92	70	89.0	75.6	82.3	+0.8	78.3	7.8	5.6	10.07	3.20	15	6.6
Hongkong	1004.7	-1.1	91	74	87.0	79.4	83.2	+1.8	78.6	8.1	8.8	16.44	0.74	28	5.1
Sandakan	1009.1	..	91	71	89.2	75.2	82.2	+0.5	76.9	8.1	6.5	3.95	3.55	8	..
Sydney, N.S.W.	1019.8	+1.9	72	37	63.4	48.5	55.9	+1.2	50.5	7.9	6.1	1.89	..	14	5.3
Melbourne	1020.4	+1.9	66	35	58.7	44.2	51.5	+1.1	46.6	9.2	7.0	1.49	0.57	18	3.6
Adelaide	1020.6	+1.5	73	39	62.9	47.6	55.3	+1.8	49.1	7.0	6.0	1.33	1.77	16	5.0
Perth, W. Australia	1016.8	-1.2	71	43	65.8	53.3	59.5	+2.7	54.8	7.6	6.1	6.52	0.42	22	4.8
Coolgardie	1019.1	+0.2	75	39	63.4	47.5	55.5	+2.7	48.7	7.1	5.1	0.59	0.67	6	..
Brisbane	1019.1	+0.8	74	38	69.7	51.0	60.3	+0.1	53.9	7.1	4.1	1.37	1.42	7	7.6
Hobart, Tasmania	1017.9	+8.6	63	38	53.0	42.0	47.5	+0.5	43.3	8.0	6.8	1.39	0.84	17	3.5
Wellington, N.Z.	1017.6	+2.7	57	35	50.5	42.0	46.3	-3.2	44.4	8.3	8.0	2.75	2.02	17	2.6
Suva, Fiji	1014.3	+0.7	87	67	80.0	70.9	75.5	+0.8	70.8	8.1	0.8	7.79	1.08	16	3.5
Apia, Samoa	1011.7	+0.1	57	68	85.2	73.7	79.5	+1.7	75.7	7.4	3.8	1.93	3.42	13	8.6
Kingston, Jamaica	1012.1	-1.7	91	70	87.3	73.5	80.4	-0.9	74.1	8.3	5.5	11.83	7.73	14	7.9
Grenada, W.I.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Toronto	1019.3	-1.4	92	45	78.2	56.8	67.5	+3.7	60.7	6.4	3.8	1.84	0.82	8	9.8
Winnipeg	1011.3	-0.5	97	35	79.7	56.2	67.9	+5.6	57.0	7.4	5.8	0.97	2.14	8	..
St. John, N.B.	1011.6	-1.9	80	40	63.4	49.1	57.3	+0.8	52.7	7.8	7.0	2.19	1.79	16	7.3
Victoria, B.C.	1016.5	-0.3	80	41	63.4	48.0	55.7	-1.3	52.0	5.8	1.15	+0.31	10	8.9	56

\* For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen.  
 ERRATA—Zomba, Nyasaland, Pressure, Mean and Diff. from normal should read April 1010.3, —1.7, May 1013.4 +0.1.

<h1 style="margin: 0;">The Meteorological Magazine</h1>				
	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="text-align: center; padding: 5px;">Vol. 68</td> </tr> <tr> <td style="text-align: center; padding: 5px;">Jan. 1934</td> </tr> <tr> <td style="text-align: center; padding: 5px;">No. 816</td> </tr> </table>	Vol. 68	Jan. 1934	No. 816
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## The Fog on New Year's Day

In London and the south-eastern part of England the New Year opened with one of the worst fogs experienced in these districts for many years. Traffic by road, rail and air was seriously disorganised, and several people lost their lives as a result of the poor visibility.

At 18h. G.M.T. on the last day of 1933 the barometric situation showed a depression some distance to the west of Iceland and another over the Mediterranean Sea. Between these two lay an elongated high pressure system extending from Scandinavia to the Azores and passing over central England, where a local maximum was indicated. Thus over Ireland and Scotland the isobars were roughly south-west to north-east, while over most of England and Wales the barometric pressure was very uniform. In this area of small pressure gradient the winds were very light, and there was little cloud except along the east coast of the southern half of England. Here the air moving round the local "high" over England just referred to encountered the comparatively cold air from the continent, and so caused a certain amount of cloud. Visibility was poor though hardly anywhere was it less than 1,100 yds. Thus conditions were very favourable for the formation of a "radiation fog."

By 7h. G.M.T. on the following morning (January, 1st, 1934) many places in the south-east part of England and the Midlands

were experiencing a visibility of less than 500 yards except along the east coast of the home counties, where the cloud had prevented the formation of fog. Meanwhile, however, the depression which had been to the west of Iceland had moved eastwards and was centred just south-east of Iceland. This caused an increase in the pressure gradient over the north-west of England. The resulting increase in wind, and the cloud which arrived with it, dispersed any fog which was tending to form there.

By 10h. G.M.T. the wind had fallen still more in most places in south-east England and the Midlands, and a thick fog covered this part of the country except on the east coast.

At 13h. G.M.T. the visibility at Croydon was less than 55 yards, and in many places in London and the suburbs large objects were quite hidden at distances of 12 yards or more. The general situation was already showing signs of improving, however. The depression near Iceland had moved slightly north-east and had deepened, and the wedge of high pressure over England had moved slightly south-east. These changes brought freshening winds from between S. and W. to an increasing area and the Midlands by now were practically clear of fog, though visibility was still not good.

The depression over Iceland continued to deepen and by 18h. G.M.T. most of the country except London and the suburbs was practically clear. The information available suggests that the southern parts of London cleared first. In the neighbourhood of Croydon the fog had completely gone by about 18h. 30m. G.M.T. In central London it persisted to a later hour, and in some of the northern districts such as Golders Green and also in the west along the river valley a thick fog lasted until after 23h. G.M.T. By the morning of January 2nd, however, conditions were back to normal.

From reports received so far it would appear that the area within a radius of about twenty miles of the centre of London suffered more than any other part of the country, though the fog was very thick further westward. In the London area the fog thickened considerably during the afternoon, and while it was most dense houses were invisible across an ordinary street. Street lamps with single incandescent mantles were hidden at about 15 yards and the green signal of some traffic-control lights at about 20 yards; the amber light, of course, showed a greater penetrating power. Normal unilluminated objects such as telegraph poles or pedestrians were hidden at distances of about 5 to 8 yards in places. During the homeward rush hour all transport services were dislocated, in one district conditions were so bad that some factory workers, familiar with the locality, walked off a path into a river. Throughout the day aircraft were prevented from leaving or landing at Croydon. In central London the fog does not appear to have been of great depth.

At about 14h. G.M.T. there was little fog at a height of about 45 feet in Kingsway, whereas in the street it was already of considerable density. Looking westwards along the Strand at about the same hour one could see enormous masses of black fog coming up in banks and separated by relatively clear patches in their upper parts.

In its general character the fog was in many ways similar to the London "particulars" of 30 years ago. The main difference was that the fog was not yellow in colour, and evidently did not contain so much of the choking sulphurous products of burning coal which was so characteristic of the older fogs. In recent years the centre of London has frequently been almost free from dense fog on the ground on occasions when the suburbs have experienced this phenomenon. This is attributable mainly to the relatively high temperature of the air in central London, due largely, it is supposed, to the prevalence of central heating in the numerous large buildings which have been recently erected, coupled with the cleaner streets and the greater areas now covered with waterproofed surfaces. The general effect of the increased temperature has been to raise a radiation fog to a height of the order of 1,000 ft. Such high fogs are the commonest type of fog now experienced in central London.

It is not yet clear why the fog of January 1st did not take the form of high fog. Possibly the explanation is to be found in the naturally stable thermal structure of a radiation fog combined with the fact that the air in the south-westerly drift, which eventually cleared the fog away, was appreciably warmer than the air it replaced. These two factors combined may have been responsible for keeping the fog on the ground.

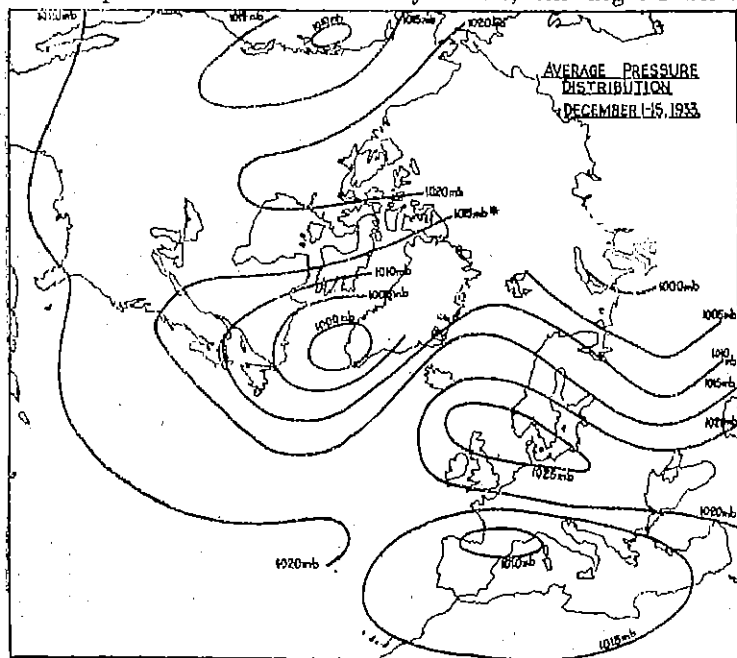
A. C. BEST.

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## The Pressure Distribution during December, 1933

The greater part of December was marked in England by an abnormal frequency of easterly winds and an intensification of the drought which had prevailed more or less throughout the year. The month opened with an intense anticyclone over Scandinavia and a depression over the northern Atlantic with two deep centres west of Iceland and over Newfoundland, which soon coalesced to form a deep depression almost stationary south of Greenland. On the 2nd the Scandinavian anticyclone began to spread south-westwards, and by the 9th extended from Scotland to Roumania. From the 11th to the 15th the main high-pressure centre lay over the Atlantic, and pressure was lowest near Newfoundland. The average pressure distribution during December 1-15th is shown in the figure. The pressure difference between Julianehaab, in the south of Greenland, and Lerwick was 29 mb.,

giving strong southerly winds over Iceland, where the average 7h. temperature was above  $40^{\circ}$  F. Over England and Ireland there was a definite gradient for easterly winds, and the average 7h. temperature at Kew was only  $33^{\circ}$  F., ten degrees below



Reykjavik. Another feature of the map is the area of almost uniform high pressure which covered the greater part of North America.

After December 15th conditions slowly changed. The depression off Newfoundland began to advance eastward, becoming complex, and the anticyclone retreated across the British Isles, reaching France on the 24th, but it was not until Christmas Day that cyclonic conditions spread over these islands. Even then the pressure distribution remained complex, and low temperatures persisted in England until the end of the year.

## Reduction of Temperature to Sea Level. The "Cold Pole"

By S. T. A. MIRRLBS, M.A.

In this country there are so few stations at an altitude of more than six or seven hundred feet that "reduction to sea level" seldom gives rise to any question.

Where there are extensive mountainous areas, and particularly for the winter season, where a large inversion of temperature at the surface may be the normal state, matters are not so simple and in the text accompanying the recently published atlas of temperature in Asiatic Russia\* the question of reduction of temperature is discussed at some length.

No satisfactory solution of the problem has been found, and the isotherms are given as reduced to sea level by the addition of  $0.5^{\circ}\text{C}$ . per 100 m., but the lines for the winter months are shown dotted over the higher mountainous parts of north-eastern and eastern Siberia, and over lofty plateau regions such as the Pamir, isotherms are omitted.

The mean temperature for the month of January over a long period at Verkhoiansk is  $-58^{\circ}\text{F}$ ., and at Jakutsk,  $-46^{\circ}\text{F}$ . On the southern slope of the mountain range between these two stations observations have been taken for a short period at Semenovski mine, at an elevation some 900 metres above the first-named stations; the mean temperature for January there, reduced to a long-period mean† is  $-21^{\circ}\text{F}$ ., and in this case the usual method of reduction to sea level breaks down, the addition of  $8^{\circ}\text{F}$ . to the temperature at the Semenovski mine station serving only to increase the anomaly. However true may be the remarks of Woeikov, quoted in the text, to the effect that the drawing of isotherms for the high ground of Central Asia is merely an exercise in drawing lines, there seems no reason why some of the boldness with which isohyets are often based on scanty data might not be applied to the drawing of isotherms. Fig. 1. is an impressionist attempt to show isotherms of actual temperature for the region in the vicinity of the "cold pole" of Siberia—or rather "poles" for, as mentioned by Dr. C. E. P. Brooks in a review‡ of the atlas, the cold pole is in reality "a series of valleys and pockets of the earth's surface, rather than a definite region."

In Fig. 1 the isotherms are at intervals of  $10^{\circ}\text{F}$ .; the isotherm in the region of Oimekon is that of  $-60^{\circ}\text{F}$ . The stations are indicated by the initial letters; V, Verkhoiansk; S, Semenovski Mine; J, Jakutsk; O, Oimekon. The contours are those of 500 and 1,000 metres, ground above 1,000 metres being shaded.

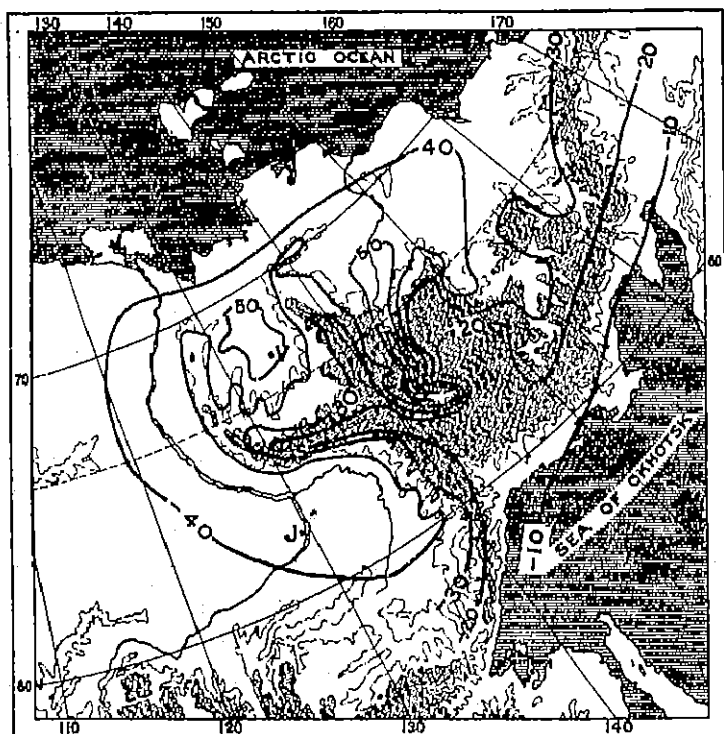
Isotherms so drawn do at least take account of such data for high levels as are available and probably give a good approximation to the facts where the topography is such that free drainage of cold air from the high stations is possible, but not in the case of enclosed basins. An example is quoted in the text of the

\* *Klima der U.S.S.R.*, Teil 1, Lief. 3, Monatsmitteln der Lufttemperatur im Asiatischen Teil der U.S.S.R. Von E. Rubinstein, Leningrad, 1931; Atlas, 1932.

† Schostakowitsch, *Contributions à l'étude du climat de la république d'Iakoute*, Leningrad, 1927.

‡ *London, Q. J. R. Meteor. Soc.*, 59, 1933, p. 285.

atlas: the station Semipalatinsk lies in nearly the same latitude as, but 1,618 metres lower than, Kosch-Agatsch, and has a mean temperature for January  $26^{\circ}\text{F}$ . warmer; the high-level station in this case is surrounded by higher ground and presumably subject to greater cooling. The same considerations presumably apply to the station in the Oimekon basin of the upper Indigirka River ( $63^{\circ} 16' \text{ N.}$ ,  $143^{\circ} 13' \text{ E.}$ , 658m. above M.S.L.), where in 1930 a mean temperature for January was recorded  $8\frac{1}{2}^{\circ}\text{F}$ . lower



than that at Verkhoiansk. The Oimekon station was set up by Professor Obrutshev, the Russian geologist who explored the region in 1926, and who was the first to draw attention to the possibility that a region experiencing lower temperatures than Verkhoiansk had been discovered\*; although the station has not been in action long enough for the probable mean temperatures to be stated accurately, it seems likely that the normal for January is below  $-60^{\circ}\text{F}$ . and the isotherms on Fig. 1 have been drawn on this assumption.

The region has not been sufficiently explored, in the

\**London, Geog. J.*, 70, 1927, p. 469.

meteorological sense, for it to be stated that there are no other "cold poles." So far as is at present known the inverted lapse-rate, as shown by data from pairs of neighbouring stations reaches an average of  $1^{\circ}$  to  $2^{\circ}$  per 100 metres in January. In particular instances these figures may be considerably exceeded, a case being quoted where the inversion as shown by observations at 7h. at neighbouring stations was  $20.7^{\circ}\text{C}$ . in 450m. ( $37^{\circ}\text{F}$ . in 1,480 feet).

The importance of such inversions of temperature in the reduction of barometric observations is evident; a rough calculation shows that under average conditions in January the reduced pressure at Semenovski mine, if the ordinary barometric tables are used, would be given as 6mb. low.

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### Discussions at the Meteorological Office

The subjects for discussion for the next two meetings are:—

January 29th, 1934.—*The absorption of sound in the atmosphere: a tentative explanation.* By Yves Rocard. (J. Phys. Radium, Paris. Vol. 55, Series 7, 1933, No. 3) (in French). *Opener.*—Mr. H. L. Wright, M.A.

February 12th, 1934.—*On the electric charge collected by water-drops falling through ionized air in a vertical electric field.* By J. P. Gott (London, Proc. R. Soc. A., Vol. 142, 1933, pp. 248-68), and *Some thundercloud problems.* By C. T. R. Wilson (Philadelphia, J. Frank. Inst., Vol. 208, 1929, pp. 1-12). *Opener.*—Mr. F. J. Scrase, M.A., B.Sc.

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### Royal Meteorological Society

The monthly meeting of this Society was held on Wednesday, December 20th, at 49, Cromwell Road, South Kensington, Prof. S. Chapman, F.R.S., President, in the Chair.

Mr. James Fairgrieve exhibited a film showing the variation of rainfall areas during a thunderstorm.

Dr. F. J. W. Whipple gave an account of recent investigations relating to the propagation to great distances of airwaves from gunfire.

*J. Glasspoole, M.Sc., and W. L. Andrew — The Exceptional Summer of 1933.*

The paper gives details of the unusual weather of the summer of 1933, and compares it with that experienced in earlier exceptional years.

The sunshine recorded over the British Isles exceeded the average in each of the four months June to September, the mean excesses being 21, 17, 35, and 33 hours, respectively. During this period many places in the south-east of England registered more



than 1,000 hours of bright sunshine, nearly 200 hours more than usual. The total sunshine during these four months fell short, however, of that recorded during June to September, 1911.

The mean temperature over the country generally exceeded the usual value in each month February to October. July, 1921, was as warm as July, 1933, and these two Julys rank as the warmest on record. The mean temperature of August, 1933, fell short of that of the Augusts of 1911 and 1899. (The highest shade temperature recorded at Greenwich Observatory since 1841, viz., 100·0° F., occurred on 9th August, 1911, while August, 1899, is the warmest calendar month on record for the British Isles as a whole.) September, 1933, was not quite as warm as the recent September of 1929, while September, 1896, was appreciably warmer. The outstanding feature of the summer of 1933 was the warmth of June to September as a whole, the mean temperature over the British Isles exceeding that of any similar period since before 1881.

The total rainfall over the British Isles during the six summer months April to September was 13·8 in., and less than that of any summer since 1870, except 1870 with 12·4 in., 1921 with 13·1 in., and 1887 with 13·7 in. The incidence of the rainfall during 1933 added to the difficulties of many water undertakings in arranging for an adequate water supply. Rainfall was abundant in February and many reservoirs were overflowing at the beginning of April. Subsequently, the slightly deficient rainfall of each month April to July, culminating in an unusually dry August, together with the loss by evaporation, resulted in a steady lowering of the level of the water in most reservoirs. Much of the rain which fell in the summer and autumn was not sufficiently prolonged to give appreciable run-off. (The rainfall was about normal in October, but the return to dry weather in November and December naturally added to the difficulties in many localities.)

The paper also includes diagrams designed to bring out the integrated effects of the variations in the weather during the whole summer period, and a note dealing with the effect of the unusual weather on the crops at Rothamsted.

## Correspondence

To the Editor, *The Meteorological Magazine*.

### Underground Water Level at Kew Observatory

The float of the water level recorder has been resting on the bottom of the well since August 17th, 1933. On November 6th the pump in the garden was removed, and soundings were taken in the boring. It was found that the level of the water was then 127 cm. above M.S.L. The lowest level which can be recorded inside the Observatory is 154 cm. By the end of the month the level in the boring had hardly changed.

This is the first time since the recorder was installed in July, 1914, that the float has rested on the bottom for such a long time. In 1929 the float rested for 13 days. It is remarkable that the water was never so low during the very dry year 1921. It is said that very little water is passing the locks on the Thames. Whether the engineering works in the neighbourhood—the building of Twickenham Bridge and the construction of large sewage works at Isleworth and the construction of wells by the Richmond Corporation in the Old Deer Park—can have affected the level of the underground water is an open question.

F. J. W. WHIPPLE.

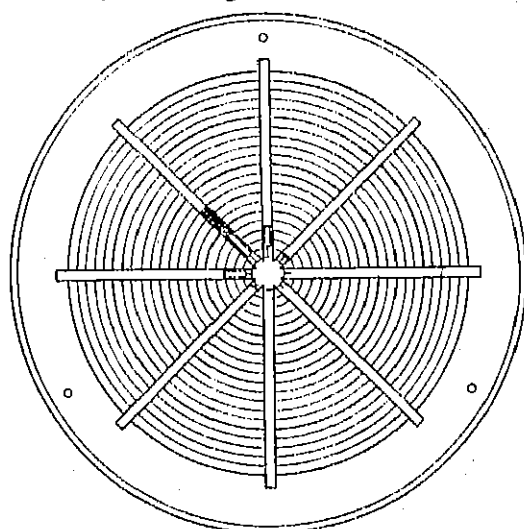
*December 9th, 1933.*

### An Instrument to facilitate the Drawing of Wind Roses

The drawing of wind roses in large numbers on a small-scale map is tedious work, and unless considerable care is used, it is difficult to attain a neat result. The instrument described in this note has been devised to render this operation quick and easy, it being possible to draw a neat eight-point rose, indicating light, moderate, and strong winds, in less than two minutes. A simple

rose indicating only the total frequencies from each direction, may be drawn in a few seconds.

The instrument, which is made from a piece of transparent celluloid about 0.065 in. thick, is shown full size in the figure. The dimensions may of course be varied to suit the scale of the wind roses which it is desired to draw.



The smallest circle on the instrument is the size of the base circle of the smallest wind rose to be drawn. The radial interval between successive circles represents 5 per cent. of frequency on the desired scale, in this case 1 inch to 100 per cent. Obviously, there will be no difficulty in drawing roses with a scale of

2 inches to 100 per cent., each interval then corresponding to  $2\frac{1}{2}$  per cent. Each fifth circle is cut slightly deeper to facilitate counting.

The eight radial slots at  $45^\circ$  intervals are  $1/16$  in. wide, and must intersect exactly at the common centre of the circles. Three very small steel points let in near the edge are a convenience in holding the instrument in position on the paper, but are not essential.

To use this instrument a small circle is drawn on the map with a bow compass. This forms the base circle of the wind rose, and is made exactly the size of one of the circles on the instrument, which is then centred over it with one of the slots pointing north on the map. The wind rose is then quickly drawn by using the sides of the slots as rulers and the circles as a scale. If the slots are about  $1/16$  in. wide, it is possible to draw a single line down the middle of the slot by inclining the pencil, or a double line by keeping the pencil close to the side of the slot. A sixteen-point rose may be drawn by first drawing the eight principal directions, then turning the instrument through  $22\frac{1}{2}^\circ$  in either direction and drawing the other eight.

An eight-point rose, showing one of the usual conventions for wind strengths, is shown in the figure as if just drawn, with the instrument still over it.

W. E. KNOWLES MIDDLETON.

*Meteorological Office, Toronto. November 16th, 1938.*

### The Parhelic Circle

The white horizontal circle associated at times with halos is seen so rarely in Australia that the following description by Mr. W. B. Lloyd of Stanhope, northern Victoria, may be worth recording. "At 9.30 p.m., August 9th, the sky was fairly clear—perhaps a slight haze, but all the larger stars bright, the only cloud being a bank well down on the western horizon and another, low in the south-east. There was no wind. A large and well-defined circle of opaque light formed a perfect circle round the zenith at the angle of altitude of the moon, which appeared set in the ring like a stone in a finger ring. With the moon as centre a segment of lunar halo, showing faint prismatic colours, mostly green and red, intersected the great white circle, terminating at each intersection in a patch of white light resembling a great nebula. It was a beautiful and remarkable sight and lasted till 9h. 42m. when some light cirrus cloud drifted across the moon, the circle faded out, as did the segment of halo and the moon remained shining transparently in the midst of a rather highly coloured circular patch of light."

On the morning of the 9th at Melbourne aeroplane observations showed that temperatures varied from  $22^\circ$  to  $-1^\circ$  F.

between 10,000 and 16,000 feet. Observations were not continued above 16,000 ft. In the afternoon winds from 7,500 to 11,000 ft. were less than 3 m.p.h., but from 11,000 to 13,000 ft. (the top of the ascent) they gradually increased to 10 m.p.h. The balloon was passing through fragments of clouds from 7,000 to 13,000 ft. and the sky was mostly covered with alto-cumulus in two layers. The lower layer was moving very slowly from east at about 10,000 ft., the higher from west-north-west at 13,000 ft. At the time a narrow anticyclone with a north-south axis, bordered by two vigorous cyclones, lay over Victoria, and the axis passed the meridians of Melbourne and Stanhope in the evening, so that the quiet conditions were if anything likely to be accentuated then.

Melbourne is nearly a hundred miles from Stanhope, but the circumstances indicated the considerable probability of still air and possibly ice crystals at a relatively low elevation over Stanhope on the night in question. Even at ordinary cirrus level the likelihood of low velocities was great, judging from experience of balloon ascents in similar meteorological situations.

Wood in his "Physical Optics" states that the white horizontal circle, mock moons, and other halo phenomena except the two halos of  $22^\circ$  and  $46^\circ$  require still air for their production. Is this distinction generally accepted? It does not seem to receive much emphasis in meteorological text books.

In his letter and sketch the observer places the mock moons on the halo, although the altitude of the moon was  $45^\circ$  at the time.

H. M. TEBLOAN.

*Central Weather Bureau, Melbourne. October 11th, 1933.*

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### Sunspots and Sunshine

I regret that the passages quoted by Mr. J. B. C. Kershaw in the December issue of this magazine from a newspaper article which appeared under my signature last June should have misled him as to the dates of recent minima of the sunspot cycle. I may, however, be permitted to point out that "approach" is not ordinarily regarded as a synonym for "arrival." The former word is admittedly somewhat vague, but it was chosen in order to avoid the use of such a cumbersome expression as "either one year, two years, or three years in advance of the minimum." The argument was that since the best astronomical opinion placed the end of the present sunspot cycle in about 1934, and since no particularly fine or hot summer had come our way in 1931 or 1932, such a season would probably arrive in 1933.

E. L. HAWKE.

*Clonwood, Rickmansworth, Herts. January 1st, 1934.*

## A Brilliant Solar Corona

Mr. Moon's reference to a brilliant lunar corona on October 31st at Hastings, reminds me that I observed a striking solar corona in London between 12 and 1 p.m. on December 16th.

In this case likewise there were three distinct rings which were very broad, red outside and green inside. The general complexion of the sky at the time was a misty orange, and the sheet of cloud producing the corona seemed to be a cross between cirro-stratus and cirro-cumulus, changing later definitely to cirro- or alto-cumulus. This indication that the cloud sheet was composed of water particles and not ice-crystals, I took to be a hint that the cold weather might be about to soften—which, as a matter of fact, it did, though I should never place much reliance on such a prognostic.

Unlike halos, coronæ round the sun are not very common, and are probably more likely to be seen in December than in other months on account of the feeble sunlight.

L. C. W. BONACINA.

*35, Parliament Hill, London, N. W. 3. December 27th, 1933.*

## NOTES AND QUERIES

### Averages of Temperature for the British Isles\*

The revised collection of average values of temperature for stations in the British Isles, which has just been issued under the above title to replace the figures for temperature in Section I of "The Book of Normals," forms a new departure in the method of preparing averages for this country, and demands more than a cursory mention in this magazine.

The first section of "The Book of Normals," published in 1919, contained monthly normals of temperature, rainfall and sunshine for the period 1881 to 1915. In accordance with the customary practice in the Meteorological Office at that time, the period of 35 years was chosen as being about the length of the Brückner cycle, and the averages for stations which had not been in existence during the whole period were "corrected" by comparison with neighbouring stations. At that time the hours of observation had remained unaltered at most stations since 1881, the chief exception being the change of the morning hour at telegraphic stations from 8h. to 7h., which occurred at the end of June, 1908, and the observations of maximum and minimum temperature always referred to the full interval of 24 hours, so that the task of compiling the normals of temperature was comparatively straightforward.

In 1921 a new conception was introduced into climatology—that of "day maximum" and "night minimum"; by which at a number of stations the temperature to be recorded as the

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\*Averages of temperature of the British Isles for periods ending 1930. London, Meteor. Office (M.O. 364), 1933, pp. 47, price 9d.

maximum on any day was the highest during the daylight hours, generally 7h. to 18h., and the recorded minimum was the lowest during the night hours, generally 18h. to 7h. On most days the day maximum and night minimum are the same as the 24-hour extremes, but in our variable climate there are many exceptions, and the extremes may occur at any hour. At "telegraphic reporting stations" the new conception has been maintained to the present day, but "health resorts" reverted to the earlier practice in 1926, while many stations have continued to use 24-hour extremes throughout.

The two sets of readings are not comparable, and in order to prepare corrected long series extensive calculations would have been required. Preliminary investigations had shown moreover that such "corrected" normals are subject to uncertainties which limit their value. Hence the decision was taken to base the new averages only on those observations which were made in the form in use at present, although this meant limiting the period available for many stations to the ten years since 1921. Thus the standard 35-year period was abandoned, with all the perilous extrapolations which it involved, and the new averages are based only on temperatures which have been directly observed. The experience gained in preparing the annual volumes of the *Réseau Mondial* has in fact shown that direct averages are preferable to "normals" artificially reduced to a standard period.

Having abandoned the 35-year standard, it would at first sight seem natural to give for each station figures for as long a period as possible. An objection to this course is that few stations exist for a long period without some change of site or surroundings. Giving due weight to this and other considerations it was decided that the averages of temperature adopted for current use in the *Monthly and Weekly Weather Reports* should in future refer to a maximum period of 30 years, and that they should be revised every five years. Thus for any station the averages will never exceed a period of 30 years, and will always be reasonably comparable with the existing site and surroundings. The present book of averages thus refers to the 30 years 1901 to 1930. This has a further advantage; about the end of the nineteenth century there was an appreciable change in the winter climate of England. This is clearly shown in the attached table, where some figures for the months of December to February, 1901-30, from the new averages are compared with those for 1871-1900 from "Temperature Tables for the British Islands."

	1901-30.			1871-1900.		
	Maxi- mum ° F.	Mini- mum ° F.	Mean ° F.	Maxi- mum ° F.	Mini- mum ° F.	Mean ° F.
Kew Observatory	45.4	36.2	40.8	43.7	34.7	39.2
Oxford ...	45.3	35.2	40.3	43.9	33.9	38.9

Thus the limitation of the averages to the present century gives a real gain in uniformity, which goes far towards counterbalancing the defect that the averages for different stations may refer to different periods. Because of the latter limitation they are described in the introduction as "averages" and not as "normals."

The new publication contains averages for each month and for the year of daily maximum, daily minimum and "mean" temperature (the arithmetical average of the daily maximum and minimum) for 244 stations. Of these, 151 are in England, the Isle of Man and the Channel Islands, 13 are in Wales, 22 in Ireland and 56 in Scotland, the remaining two being Gibraltar and Malta. They show that the highest mean temperature for the year is found in Penzance ( $52.5^{\circ}$  F.), Jersey ( $52.4^{\circ}$  F.), and Scilly ( $52.3^{\circ}$  F.), and the lowest at high-level Scottish stations such as Braemar ( $43.1^{\circ}$  F.), where the average daily minimum is below freezing point from November to March. The highest summer temperatures are found in the London area.

A similar publication giving averages of sunshine for the period 1901 to 1930 is in course of preparation. The new averages for both elements were adopted for the purpose of the *Monthly Weather Report* from January 1st, 1934.

### The Rainfall of 1933

The rainfall of 1933 over the British Isles as a whole was 81 per cent. of the average. Thus the remarkable run of ten wet years, which commenced in 1923, has been broken. 1933 ranks as the driest year since 1870, with but one exception, viz. 1887 with 77 per cent., being slightly drier than 1921 with 82 per cent. Provisional estimates of the general rainfall for 1933 are given below, both in actual inches and as percentages of the average, together with similar values for the dry years 1921 and 1887.

	1933.		1921.		1887.	
	in.	%	in.	%	in.	%
England and Wales ...	29.3	83	24.7	70	26.3	74
Scotland ...	39.9	79	49.8	99	40.2	80
Ireland ...	33.2	77	38.1	88	33.2	77
British Isles ...	33.5	81	34.0	82	31.7	77

It will be seen that over England and Wales 1933 was not as dry as 1921, but since 1870 the only other comparable years were 1893 with 83 per cent. and 1870 with 82 per cent. Over Scotland 1933 was drier than any year since before 1870, although 1887 and 1870 both gave 80 per cent. Over Ireland 1933 ranks with 1887 as giving the least rainfall since before

1870. The rainfall of 1933 was remarkable in that each country experienced a large deficiency, so that the distribution resembled 1887 rather than 1921, when the deficiency was most marked in the south-eastern half of England and Wales.

General values for each month are set out in the table below, both as percentages of the average for the period 1881 to 1915 and in actual inches of rainfall:—

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	%	%	%	%	%	%	%	%	%	%	%	%
England & Wales	98	100	110	70	97	92	82	88	94	103	59	29
Scotland ..	103	123	94	95	69	85	108	75	41	107	67	32
Ireland ..	90	100	90	65	114	94	90	58	45	83	40	49
British Isles ..	95	140	101	75	94	91	90	51	70	100	59	34
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
England & Wales	2.8	4.1	3.2	1.5	2.2	2.2	2.8	1.8	2.4	4.1	2.1	1.1
Scotland ..	5.1	5.1	2.0	2.8	2.1	2.4	4.1	3.4	1.0	5.2	3.0	1.9
Ireland ..	3.7	3.0	3.3	1.8	3.1	2.7	3.0	2.4	1.4	3.4	2.1	2.4
British Isles ..	3.0	4.0	3.2	1.9	2.4	2.4	2.9	2.0	2.2	4.2	2.5	1.9

February alone gave an appreciable excess of rainfall over the British Isles generally, but the total amount from January to July was only 2 in. short of the average. The deficiencies were outstanding, however, only in August, November and December. August, 1933, was considerably wetter than August, 1880, with 1.5 in. and only a little drier than August, 1932, with 2.3 in. November, 1933, was also appreciably wetter than that of 1896 with 1.8 in. December, 1933, was just drier than that of 1926 with 1.7 in., which had previously been the driest December since before 1870.

The rainfall during 1933 was remarkable for the long sequence of nine consecutive months in none of which was the average amount exceeded. The total rainfall for November and December, 1933, of 4.1 in. was less than that during any similar period back to 1870, the previous driest November to December being that of 1879 with 4.2 in. The total rainfall during the nine months April to December, 1933, of 22.1 in. was also less than that of any similar period back to 1870, the next driest April to December being those of 1921 and 1887, both with 24.1 in.

The total rainfall for 1933 exceeded the average, for the standard period 1881 to 1915, to the east of the Pennines from Sunderland to Goole and in parts of Hampshire. No part of England appears to have received more than 110 per cent. of the average, and no part of Wales, Scotland or Ireland as

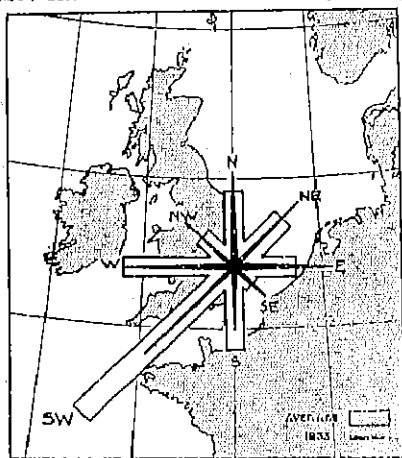


much as the average. Over England and Wales less than 70 per cent. occurred over a large area including London, Croydon, Harpenden and Southminster, and also in the neighbourhood of Bideford, the Cheshire Plain and Plinlimmon. More than 90 per cent. occurred over a large area between Newcastle and Retford, stretching as far west as Barnard Castle, Bradford and Barnsley, in parts of Wiltshire, Hampshire, south Devon and Cornwall, and at Birmingham and Lowestoft. Over Scotland the percentages varied from rather more than 90 per cent. in Aberdeenshire and western Argyllshire to about 70 per cent. at Perth, Girvan, St. Andrews, Lairg and Stornoway. Over Ireland the percentages varied from rather more than 85 per cent. in the west of Galway and Mayo and near Dublin and Wexford, to less than 70 per cent. over large areas in Londonderry, Armagh, Limerick and the south-west of Cork.

J. GLASSPOOLE.

### Lack of SW. Winds at Kew

With reference to the interesting paper by Dr. Glasspoole and Mr. Andrew summarised on p. 283, the comparative lack of SW. winds during the period May to November, 1933, deserves notice. To me this deficiency of genial winds has been apparent, and I find that the frequency of SW. winds at Kew during this period has been only 18 per cent. compared with a normal of about 30 per cent. The accompanying wind rose illustrates the point: instead of the usual Kew wind rose with the long tail to south-west a more general distribution is shown. This fits in well with the opening out of the isobars referred to in Dr.



Brooks' section on pressure conditions.

R. M. POULTER.

### Weather Proverbs

There are many weather proverbs relating to animals, and in this connexion the following may be of interest.

To an account of a severe storm recorded in the log of one of H.M. ships in the Persian Gulf the following note is

appended:—"The first indication of the approach of the storm observed was the behaviour of the ship's cats. For the previous week they had been very lazy and sleepy, but about twelve hours before the storm, they went quite mad, rushing wildly about and biting people's feet."

## Review

*The effect of topography on the direction and velocity of wind:*

II. Geophys. Mag., Tokyo, 7, 1933, p. 9. *Direction and velocity of wind in the vicinity of a wind tower.* Ibid. 7, 1933, p. 19. *On the influence of topography on the microbarometric observations.* Ibid. 5, 1932, p. 223. By H. Arakawa.

In the first two of these three papers H. Arakawa discusses the flow of air in the neighbourhood of obstacles and uses a modification of Lamb's analysis to obtain the stream functions for a mountain of the shape of a semi-ellipsoid rising from a flat plane. In the second he discusses a somewhat similar problem with a rectangular tower. The results he derives are concisely shown by wind roses. In the case of roses in which the wind from each direction is of equal velocity over the unobstructed plane, the roses near the top of the mountain or the tower are deformed in such a way that the strongest winds are at right angles to the major axis of the ellipsoid or the longer side of the rectangle. A similar effect is found in the case of roses where the frequency is the same from each direction over the unobstructed plane. Such a result is what would be expected in the case of an ideal fluid, and the value of the papers is to be measured by the extent to which numerical figures can be given which are applicable to the actual facts of wind blowing over the earth. One feels that the author is dealing rather with the realms of the (mathematical) Gods on High Olympus "above the smoke and stir of this dim spot, that men call Earth," for turbulence must radically alter the numerical results. The author is fully aware of this, and in what is probably the most valuable part of the first of these papers he discusses the effect which a vortex in the rear of a semi-cylindrical mountain would have in altering the distribution of wind over the ridge. The effect of such a vortex is to modify the distortion of both the velocity and direction roses from the distribution over the unobstructed plane.

In the third paper Arakawa draws attention to the remarkable behaviour of the microbarograph at the observatory on Mt. Huzi, which shows large oscillations when the microbarograph at Tokyo shows very little fluctuation. In part he ascribes these to the oscillations of air set up in the crater of the moun-

tain, but he goes on to consider how far the presence of a mountain may magnify the wave motion in a surface of discontinuity lying above it. He concludes that at the top of the mountain the pressure differences due to the waves should be considerably enhanced. This leads him to a brief review of the association between microbaric oscillations and the presence of discontinuities. To detect the discontinuity he uses marked changes of upper winds, as disclosed by pilot balloons, rainfall and the presence of wave cloud and finds the agreement is close. It would certainly seem that in Japan the microbarograph may, under suitable conditions, be of considerable use in detecting the arrival of a front, especially above a mountain station, and it is not unnatural to ask whether the instrument could not be used in this way in the British Isles. No very serious attempt appears to have been made in this country to correlate microbarograms with synoptic charts, though it was Goldie\* who first pointed out the association of the wave motion at discontinuities and microbarographic oscillations.

In 1929 D. E. Davies† found less close relationship between atmospheric oscillations and rainfall than Fujiwhara and Kanagawa‡ had done in Japan. That may, however, be explained by the difference in type of front that is found over Japan and England. Over the former depressions are comparatively young, and probably few fronts do not give rain, but in England, when the decayed fronts of dead Atlantic depressions are being carried over, there are frequent occasions when a discontinuity may be present without giving rain.

It would seem that further investigation in this country might lead to some interesting and practical results.

C. S. DURST.

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### Books Received

*Jaarboek, Koninklijk Nederlandsch Meteorologisch Instituut*, 1931. A. Meteorologie, B. Aard-Magnetisme (Nos. 97 and 98). Utrecht, 1932.

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### News in Brief

Dr. and Mrs. G. C. Simpson invited the staff of the Meteorological Office to a dance at Australia House on December 19th. Over 200 members of the staff and guests attended and spent a very enjoyable evening. An interesting interlude was provided by Mr. J. M. Stagg and Mr. W. A. Grinstead, who described and illustrated their experiences at Fort Rae during the Polar Year.

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\* A. H. R. Goldie, *Q.J.R. Meteor. Soc.* 51, 1925, p. 239.

† *Meteor. Mag.*, 64, p. 191.

‡ *Geophys. Mag.*, 1, p. 304.

## The Weather of December, 1933

Pressure was above normal over Spitsbergen, Iceland, Europe from the extreme north to a line joining Dijon and Bucharest, most of the North Atlantic including the Azores and Bermudas, Florida, California, north central United States, Canada and Alaska, the greatest excesses being 17.3mb. at Lerwick and 13.2mb. at Kodiak. Pressure was below normal in a belt extending from Greenland across Newfoundland and Nova Scotia to the United States and also over southern Europe, the greatest deficits being 6.7mb. at Ekaterinburg; 5.6mb. at Algiers and 4.5mb. at Julianehaab. Temperature was above normal in Spitsbergen and northern Scandinavia but below normal in the British Isles, southern Scandinavia and central and southern Europe. Precipitation was generally deficient except in northern Norway and the mountainous parts of Sweden. In west Svealand and west Götaland it was only about 10 per cent. of the normal.

The weather of December over the British Isles was persistently cold, except in the extreme north and unusually dry with much fog in England and south Scotland, while pressure was much above normal (see p. 279). At Eskdalemuir and Gorleston it was the driest December since records began in 1910 and 1871, respectively. Sunshine records were variable, though usually deficient in the east and in excess in the west. On the 1st and 2nd a trough of low pressure moved across the western districts with gales in the north and west and heavy rain locally, 2.17 in. fell at Fofanny (Co. Down) and 2.10 in. at Holne (Devon), on the 1st. Snow was reported in Wales and Scotland. On the 2nd the anticyclone over Scandinavia spread westwards across the country and the weather became mainly dry and cold with E. to SE. winds, except in the extreme north-west where milder conditions and scattered showers were experienced. On the 6th and 7th fog was widespread in England and some low maximum temperatures were recorded on the 6th, 23° F. at Manchester. On the 7th a shallow trough of low pressure passing across the country caused drizzle generally. From the 8th-11th the influence of the anticyclone again predominated as it moved westwards to the Atlantic and very cold, cloudy but mainly dry conditions were experienced generally but with snow showers locally. On the 11th and 12th a depression passed from Iceland to the Bay of Biscay and rain, sleet or snow were experienced generally both then and on the 13th, when this depression developed considerably over France, giving fresh to strong E. to NE. winds over southern England with, on the 13th and 14th, gales locally. On the 13th, however, the anticyclone extending from the Azores to Iceland began to move south and by the 16th had spread over the whole of the British Isles, displacing this depression. Cold quiet anticyclonic conditions were experienced from then until the 21st with widespread fog on the 17th and 19th-21st in England and south Scotland.

Conditions throughout this period were finer in the west and north. On the 21st a low-pressure area moving north-eastwards approached our western seaboard, and in the west and north the winds became S—SW., fresh to strong with gales locally, and the weather mild and unsettled until the 26th. Meanwhile the south-eastern districts remained under the influence of the anti-cyclone over France with dry, mainly dull, conditions and much local mist or fog. On the 27th a depression off north-west Ireland moved south-east and from then until the 30th, rain or drizzle accompanied by much mist or fog in England and south Scotland occurred generally, with heavier rain in the west on the 27th, 1.30 in. at Abbey Leix (Co. Leix) and at Broadford (Co. Clare), and snow or sleet at a few places—gales occurred locally in the south-west on the 28th. On the 31st there was a renewal of anticyclonic conditions, but with a continuance of the mist or fog in England and south Scotland and with drizzle in the west. Among the lowest temperatures recorded in the month were 15° F. in the screen at Rhayader on the 6th and 13° F. at Dalwhinnie on the 10th and 14th, and on the ground 7° F. at Dalwhinnie on the 10th and 11th, and 9° F. at Collumpton on the 10th. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway	31	+ 8	Liverpool	31	—12
Aberdeen	30	+ 3	Ross-on-Wye	45	+ 3
Dublin	29	—19	Falmouth	57	+ 2
Birr Castle	51	+ 8	Gorleston	41	— 4
Valentia	66	+25	Kew	10	—18

The special message from Brazil states that the rainfall in the northern regions was irregular in distribution with an average 0.12 in. above normal, in the central regions generally plentiful with 2.01 in. above normal, and in the southern regions scarce with 0.39 in. below normal. Six anticyclones passed across the country. The temperature was abnormally low. The crops generally were in good condition, except in Rio Grande, where they were suffering from lack of rain during the last decade. The cereals were still affected by locust. At Rio de Janeiro pressure was 0.5 mb. below normal and temperature 2.0° F. below normal.

*Miscellaneous notes on weather abroad culled from various sources.* Fifteen degrees of frost were registered at Braila (Roumania) during the nights of the 2nd-3rd and 3rd-4th. During the severe storm over the southern North Sea on the 3rd and 4th two light-ships went adrift off the Belgian and French coasts. By the 6th it was reported from Leningrad that solid ice had formed as far as Kronstad, but that a canal was being kept open by icebreakers. On the 9th the inland canal and waterway at Antwerp were frozen and navigation closed. On the 12th navigation closed at Yxpila, Jacobstad and Kristinestad in the

Baltic. Severe weather with very low temperatures and storms prevailed over the greater part of Europe about the middle of the month. Heavy snow occurred in northern Italy and along the Riviera; Venice lay under about 3 ft. of snow on the 14th, but on the 15th the tide rose 4 ft. above the normal and the city was flooded. On the 17th a temperature of  $-4^{\circ}$  F. was recorded at Nyons (Drôme, south France), and the railway line from Paris to Marseilles was blocked by snow over 9 ft. deep near Alais, the cold being intensified by the mistral. Ski-ing conditions were excellent in Switzerland during this time. There was a marked rise in temperature over France about the 20th, and temperature was also less severe in Switzerland over Christmas, but in Austria snowdrifts and avalanches caused dislocation of traffic. Christmas was mild in Iceland. Towards the end of the month heavy snow was again experienced in Piedmont and Lombardy and small snowfalls occurred in Switzerland. Navigation closed at Vasa, Finland, on the 30th. (*The Times*, December 5th-January 2nd.)

The heavy rains in north Morocco early in the month caused serious floods about the 12th. Severe wintry weather followed from about the 14th-20th with heavy snow in the neighbourhood of Fez. The mail train from Bloemfontein to Durban was derailed on the 15th 33 miles from Bloemfontein, owing to a subsidence in the line caused by the heavy rains. Extensive storms followed by floods did much damage in South Africa towards the end of the month, the railways being washed away at several points. (*The Times*, December 13th-30th.)

Severe cold and blizzards were experienced in Canada during the latter part of the month, a temperature of  $-66^{\circ}$  F. being recorded at Mayo, Yukon, on the 29th. On the 31st, however, there was a change to mild weather with sleet and rain. Temperature was considerably above the average over many districts of the United States during the greater part of the month. A heavy snowstorm, however, began in New York on Christmas night, and from then onwards severe cold and snowstorms occurred generally over the whole country until the temperature began to rise on the 31st—100 people died of the cold. Precipitation was irregular in distribution in the United States. Widespread floods followed heavy rains in California on the 30th and 31st; 66 people are known to have been killed or injured. (*The Times*, December 27th-January 3rd, and *Washington, D.C., U.S. Dept. Agric., Weekly Weather and Crop Bulletin* and *Toronto, Canadian Daily Weather Report*.)

### General Rainfall for December, 1933

England and Wales	...	29	per cent of the average 1881-1915.
Scotland	...	32	
Ireland	...	40	
British Isles	...	34	

## Rainfall: December, 1933: England and Wales.

Co.	STATION	In.	Per- cent. of Av.	Co.	STATION	In.	Per- cent. of Av.
<i>Land</i>	Camden Square .....	·30	15	<i>Leics.</i>	Thornton Reservoir ...	·40	18
<i>Kent</i>	Tenterden, Ashendon ...	·57	18	"	Belvoir Castle .....	·35	14
"	Folkestone, Boro. San.	·83	...	<i>Kent</i>	Ridlington .....	·35	14
"	St. Peter's, Hildersham ...	...	...	<i>Lincolns</i>	Boston, Skirbooke .....	·07	31
"	Eden' bldg., Falconhurst ...	·62	19	"	Cranwell Aerodrome ...	·37	17
"	Sevenoaks, Speldhurst ...	·50	...	"	Skewness, Marine Gdns ...	·50	25
<i>Sus.</i>	Compton, Compton Ho.	·92	22	"	Louth, Westgate .....	·08	24
"	Patching Farm .....	1·25	37	"	Brigg, Wrawby St. ...	·33	...
"	Eastbourne, Wil. Sq.	1·31	36	<i>Notts</i>	Worksop, Hodsok ...	·30	15
"	Heathfield, Barklye ...	1·08	29	<i>Derby</i>	Derby, L. M. & S. Rly.	·32	12
<i>Hants.</i>	Ventnor, Roy. Nat. Hos.	1·00	80	"	Buxton, Terr. Slopes ...	·52	9
"	Fordingbridge, Oaklands	1·01	25	<i>Ches.</i>	Runcorn, Weston Pt. ...	·76	24
"	Ovington Rectory .....	·64	10	<i>Lancs.</i>	Manchester, Whit Pk.	·44	14
"	Sherborne St. John ...	·45	14	"	Stourthurst College ...	·73	15
<i>Herts.</i>	Wolwyn Garden City ...	·51	21	"	Southport, Hesket Pk.	·83	20
<i>Bucks.</i>	Slough, Upton .....	·48	19	"	Lancaster, Greg Obsy.	·70	10
"	H. Wycombe, Flackwell	·40	16	<i>Yorks.</i>	Wath-upon-Deane ...	·25	11
<i>Oxf.</i>	Oxford, Mag. College ...	·24	10	"	Wakesfield, Clarence Pk.	·52	21
<i>Nor.</i>	Pitsford, Sedgemoor ...	...	...	"	Oughtershaw Hall .....	1·00	...
"	Oundle .....	·39	...	"	Wetherby, Ribston H.	·77	31
<i>Beds.</i>	Woburn, Exptl. Farm.	·38	16	"	Hull, Pearson Park ...	·51	21
<i>Cam.</i>	Cambridge, Bot. Gdns.	·28	15	"	Holme-on-Spalding ...	·68	28
<i>Essex.</i>	Chelmsford, County Lab.	·55	25	"	West Witton, Ivy Ho.	·78	20
"	Lexden Hill House ...	·45	...	"	Felixkirk, Mt. St. John	·09	41
<i>Suff.</i>	Haughley House .....	·45	...	"	York, Museum Gdns.	·52	28
"	Campsea Asho. ....	·70	34	"	Plecker, Hungate ...	1·03	41
"	Lowestoft Sec. School	·08	20	"	Scarborough .....	·87	37
"	Bury St. Ed., Westley H.	·54	22	"	Middlesbrough .....	1·61	83
<i>Norw.</i>	Wells, Holkham Hall	·74	30	"	Baldersdale, Hury Res.	·80	22
<i>Wilts.</i>	Devizes, Highclere ...	·63	21	<i>Durh.</i>	Ushaw College .....	2·00	80
"	Calne, Castleway .....	·43	14	<i>Nor.</i>	Newcastle, Town Moor	1·37	57
<i>Dor.</i>	Evershot, Melbury Ho.	1·03	20	"	Bellingham, Highgreen	1·08	30
"	Weymouth, Westham ...	1·02	29	"	Lilburn Tower Gdns ...	2·04	78
"	Shaftesbury, Abbey Ho.	·75	21	<i>Cumb.</i>	Carlisle, Scalby Hall	·85	20
<i>Devon.</i>	Plymouth, The Hoe ...	2·48	49	"	Borrowdale, Seathwaite	4·00	20
"	Holne, Church Pk. Cott.	8·33	39	"	Borrowdale, Moraine ...	2·04	17
"	Teignmouth, Den Gdns.	2·88	70	"	Keswick, High Hill ...	·41	6
"	Cullompton .....	1·65	38	<i>West.</i>	Appleby, Castle Bank	1·15	29
"	Sidmouth, Sidmount ...	2·72	69	<i>Mon.</i>	Abergavenny, Larchfd	1·65	37
"	Barnstaple, N. Dev. Ath.	1·98	44	<i>Glam.</i>	Yatalysora, Worn Ho.	2·06	25
"	Dartm'r, Cranmore Pool	2·70	...	"	Cardiff, Ely P. Stn. ...	2·05	40
"	Okhampton, Uplands ...	2·71	38	"	Treharbert, Tynywain	8·17	...
<i>Corn.</i>	Redruth, Trewinglo ...	2·71	48	<i>Carm.</i>	Carmarthen Friary ...	1·42	25
"	Penzance, Morrab Gdn.	2·48	44	<i>Pemb.</i>	Haverfordwest, School	2·84	41
"	St. Austell, Trevanna ...	8·93	65	<i>Card.</i>	Aberystwyth .....	1·58	...
<i>Som.</i>	Cheyton Mendip .....	1·11	21	<i>Rad.</i>	Blm W. W. Tyrmynydd	1·92	23
"	Long Ashton .....	1·48	37	<i>Mont.</i>	Lake Vyrnwy .....	1·77	26
"	Street, Millfield .....	·82	24	<i>Flint.</i>	Sea-Land Aerodrome ...	·51	20
<i>Glos.</i>	Blookley .....	·39	...	<i>Aber.</i>	Dolgellau, Bontddu ...	2·20	38
"	Omnecoster, Gwynfa ...	·56	17	<i>Carm.</i>	Llandudno .....	1·28	44
<i>Here.</i>	Ross, Birchlea .....	·77	26	"	Snowdon, L. Llydaw ...	2·82	...
<i>Salop.</i>	Church Stretton .....	·67	20	<i>Ang.</i>	Holyhead, Salt Island	2·33	50
"	Shifnal, Hatton Grange	·52	20	"	Lligwy .....	1·48	...
<i>Staffs.</i>	Market Drayton, Old Sp.	·40	14	<i>Isle of Man</i>			
<i>Worc.</i>	Omborsley, Holt Lock	·42	16		Douglas, Boro' Cem. ...	2·08	42
<i>War.</i>	Alcester, Ragley Hall ...	·48	20	<i>Guernsey</i>			
"	Birmingham, Edgbaston	·49	18		St. Peter P't. Grange Rd.	2·34	57

## Rainfall: December, 1933: Scotland and Ireland.

Co.	STATION	In.	Per- cent of Av.	Co.	STATION	In.	Per- cent of Av.
<i>Wig.</i>	Pt. William, Monreith	1'87	41	<i>Suth.</i>	Melvich	0'97	28
	New Luce School	2'79	50		Loch More, Achfary	2'35	25
<i>Kirk.</i>	Dalry, Glendarroch	2'02	28	<i>Caith.</i>	Wick	1'09	35
	Carnphairn, Shiol	2'29	25	<i>Ork.</i>	Doorness	1'61	38
<i>Dumf.</i>	Dumfries, Crichton, R.I.	0'6	14	<i>Shet.</i>	Lerwick	1'93	40
	Eskdalemuir Obs.	1'31	19	<i>Cork.</i>	Cahernagh Rectory	2'38	...
<i>Roxb.</i>	Braxholm	0'83	28		Dunmanway Rectory	2'72	34
<i>Selk.</i>	Ettleok Manor	0'7	16		Cork, University Coll.	1'60	32
<i>Peeb.</i>	West Linton	0'9	...		Ballinaurra	1'45	28
<i>Berw.</i>	Marchmont House	1'26	45	<i>Kerry.</i>	Valentia Obey	2'98	45
<i>E. Loth.</i>	North Berwick Res.	1'42	66		Gearhameen	4'10	38
<i>Midl.</i>	Edinburgh, Roy. Obs.	0'79	34		Darrynane Abbey	2'49	42
<i>Lan.</i>	Auchtyfardo	0'8	...	<i>Wat.</i>	Waterford, Gortmore	2'38	61
<i>Ayr.</i>	Kilmarnock, Kay Pk.	1'62	...	<i>Tip.</i>	Nenagh, Cas. Lough	1'84	40
	Girvan, Pilmoro	2'16	30		Roserea, Timoney Park	1'38	...
<i>Renf.</i>	Glasgow, Queen's Pk.	0'4	15		Cashel, Ballinamona	1'04	45
	Groonook, Prospect H.	1'58	19	<i>Linn.</i>	Foynea, Coolmanes	1'45	31
<i>Bute.</i>	Rothessay, Ardenacraig	2'10	...		Castleconnel Rec.	2'48	...
	Douglas Lodge	2'68	...	<i>Clare.</i>	Inagh, Mount Callan	2'30	...
<i>Arg.</i>	Argoour House	4'12	...		Broadford, Hurdlest'n	2'45	...
	Glen Etivo	...	...	<i>Wexf.</i>	Gorey, Courtown Ho.	2'61	66
	Oban	2'00	...	<i>Wick.</i>	Rathnew, Clonmannon	3'01	...
	Poltalloch	3'10	49	<i>Carl.</i>	Haastown Rectory	2'50	61
	Inveraray Castle	4'45	45	<i>Lein.</i>	Blandsfort House	2'56	70
	Islay, Eallabus	3'48	58		Mountmellick	2'16	...
	Mull, Benmore	...	...	<i>Offaly.</i>	Birr Castle	1'93	59
	Tirree	2'54	49	<i>Dublin.</i>	Dublin, FitzWm. Sq.	1'48	60
<i>Kinn.</i>	Loch Leven Sluice	1'12	28		Balbriggan, Ardglan	1'98	69
<i>Perth.</i>	Loch Dhu	1'95	18	<i>Meath.</i>	Boonpara, St. Cloud	2'20	...
	Balquhiddler, Stronvar	1'65	...		Kells, Headfort	1'84	48
	Crieff, Strathearn Hyd.	0'1	20	<i>W. M.</i>	Monte, Coolatora	2'74	...
	Blair Castle Gardens	0'73	10		Mullingar, Belvedere	2'03	71
<i>Annap.</i>	Kettins School	1'22	37	<i>Long.</i>	Castle Forbes Gdns.	2'22	60
	Pearse House	1'02	...	<i>Gal.</i>	Galway, Grammar Sch.	1'75	...
	Montrose, Sunnyside	1'64	56		Ballynahinch Castle	3'26	43
<i>Aber.</i>	Braemar, Bank	1'14	30		Ahasragh, Clonbrook	1'79	38
	Logie Coldstone Sch.	1'24	44	<i>Munro.</i>	Blacksod Point	3'21	52
	Aberdeen, King's Coll.	1'91	59		Mallarnamy	3'82	...
	Fyvie Castle	2'02	59		Westport House	2'08	36
<i>Moray.</i>	Gordon Castle	0'45	17		Delphi Lodge	5'07	42
	Grantown-on-Spey	...	...	<i>Sligo.</i>	Markree Obey	1'83	38
<i>Nairn.</i>	Nairn	0'28	13	<i>Cavan.</i>	Crossdoney, Kavt. Cas.	2'84	...
<i>Inver.</i>	Ben Alder Lodge	0'75	...	<i>Ferm.</i>	Enniskillen, Portora	...	...
	Kingussie, The Birches	0'37	...	<i>Arm.</i>	Armagh Obey	1'64	62
	Inverness, Culduthel R.	0'25	...	<i>Down.</i>	Fofanny Reservoir	4'09	...
	Loch Quoich, Loan	15'30	...		Senforde	2'03	40
	Glenquoich	2'76	18		Donaghadee, O. Stn.	2'48	78
	Arisaig, Fairo-na-Sgair	2'54	...		Banbridge, Milltown	1'41	40
	Fort William, Glasdrum	2'03	...	<i>Antr.</i>	Belfast, Cavohill Rd.	2'16	...
	Skye, Dunvegan	3'07	...		Aldergrove Aerodrome	1'61	47
	Barra, Skallary	2'72	...		Ballymena, Harryville	2'62	60
<i>R. &amp; C.</i>	Achesa, Ardross Castle	0'41	10	<i>Lon.</i>	Garvagh, Moneydig	2'38	...
	Ullapool	0'69	11		Londonderry, Oreggan	2'31	53
	Achnashellach	1'65	16	<i>Tyr.</i>	Omagh, Edensol	2'38	60
	Stornoway	1'59	25	<i>Don.</i>	Malin Head	1'88	...
<i>Suth.</i>	Lairg	0'88	21		Millford, The Manor	2'20	40
	Tongue	0'84	17		Killybegs, Rockmoun.	...	...



## Climatological Table for the British Empire, July, 1933

STATIONS	PRESSURE		TEMPERATURE							Mean Cloud Amt	PRECIPITATION		BRIGHT SUNSHINE		
	Mean of Day M.S.L.	Diff. from Normal	Absolute		Mean Values						Amt. in.	Diff. from Normal	Days	Hours per day	Per- cent. of age of possible
			Max.	Min.	Max. ° F.	Min. ° F.	max. 1/2 and min. ° F.	Diff. from Normal ° F.	Wet Bulb ° F.						
London, Kew Obsy. . . . .	1017.8	+2.0	88	52	75.9	58.1	67.0	+4.3	59.2	1.74	0.43	9	7.9	49	
Gibraltar. . . . .	1017.9	+1.1	90	61	82.3	66.6	74.5	-0.3	85.5	0.00	0.03	0	..	..	
Malta . . . . .	1017.4	+2.7	94	66	82.7	70.4	76.5	-1.3	63.7	0.02	0.03	1	12.5	88	
St. Helena . . . . .	1017.2	+0.6	65	58	80.4	55.0	57.7	-0.8	55.6	4.78	..	26	..	..	
Preston, Sierra Leone . . .	1015.1	+2.4	87	65	82.5	69.0	76.2	-2.4	74.8	31.76	8.82	26	..	..	
Lagos, Nigeria . . . . .	1013.9	+0.7	86	72	82.7	74.7	78.7	+0.7	74.8	19.49	8.99	25	3.0	24	
Kaduna, Nigeria . . . . .	1014.2	-0.7	89	65	84.7	69.1	76.9	+3.3	71.6	8.63	1.99	22	6.0	48	
Zomba, Nyasaland . . . . .	1018.2	-0.3	85	45	78.3	52.2	62.7	+0.7	56.3	0.22	0.18	3	..	..	
Salisbury, Rhodesia . . . . .	1021.3	-0.2	78	36	71.0	43.9	57.5	+1.4	49.7	0.00	0.03	0	9.4	84	
Cape Town. . . . .	1019.8	-1.5	80	36	61.3	46.8	54.1	-0.6	47.0	3.67	0.05	11	..	..	
Johannesburg . . . . .	1022.1	-0.9	69	32	61.1	41.1	51.1	+0.7	41.9	0.01	0.32	1	9.0	84	
Mauritius . . . . .	1021.5	+1.1	77	53	73.9	60.3	67.1	-1.2	63.5	2.24	0.25	24	7.2	66	
Calcutta, Alipore Obsy. . .	1000.0	+0.8	92	75	88.1	79.5	83.8	+0.1	79.2	8.6	4.48	17*	..	..	
Bombay . . . . .	1004.2	+0.3	91	74	87.7	78.5	83.1	+1.7	77.8	17.18	10.14	15*	..	..	
Madras . . . . .	1004.3	-0.2	101	73	96.5	79.8	88.1	+0.5	77.1	1.08	2.76	4*	..	..	
Colombo, Ceylon . . . . .	1010.0	+0.9	85	72	83.5	76.6	80.1	-1.1	76.6	6.58	2.15	21	4.7	38	
Singapore . . . . .	1008.9	-0.0	93	71	88.1	75.0	81.5	+0.2	77.6	4.73	2.06	14	5.7	47	
Hongkong . . . . .	1005.5	+0.8	93	76	87.9	78.8	83.3	+0.8	78.3	14.31	0.11	20	6.8	51	
Sandakan . . . . .	1008.9	..	91	72	88.4	74.8	81.6	-0.2	77.0	7.74	1.02	17	..	..	
Sydney, N.S.W. . . . .	1018.8	+0.5	76	41	61.1	48.5	54.3	+2.1	50.6	3.48	1.32	18	4.1	41	
Melbourne . . . . .	1019.7	+0.8	66	32	57.1	41.4	49.3	+0.8	44.4	5.7	0.39	14	4.2	43	
Adelaide . . . . .	1020.3	-0.0	70	37	59.7	42.5	51.1	-0.7	45.6	1.75	0.89	15	5.2	52	
Perth, W. Australia . . . .	1021.2	+2.2	71	38	62.4	46.3	54.3	-0.9	49.3	4.99	1.57	16	6.6	64	
Coolgardie . . . . .	1021.7	+1.9	73	37	59.7	42.6	51.1	-0.1	45.5	0.72	0.15	6	..	..	
Brisbane . . . . .	1018.1	-0.3	73	39	67.5	51.8	59.7	+1.2	54.1	3.23	1.03	10	5.8	55	
Hobart, Tasmania . . . . .	1017.5	+3.8	60	34	53.2	40.3	46.7	+1.0	41.9	1.16	1.02	12	4.8	51	
Wellington, N.Z. . . . .	1022.6	+8.7	60	36	50.4	42.5	46.5	-1.5	44.3	7.6	0.37	19	2.5	26	
Suva, Fiji . . . . .	1015.3	+1.3	86	62	78.6	67.5	73.1	-0.3	67.7	1.88	3.05	16	5.5	49	
Apia, Samoa . . . . .	1012.0	+0.1	86	70	83.9	72.7	78.3	+1.1	74.5	5.95	2.97	15	8.1	71	
Kingston, Jamaica . . . . .	1013.6	-1.1	92	69	83.0	73.5	80.7	-1.0	73.1	9.86	8.24	10	8.2	63	
Grenada, W.I. . . . .	1015.4	+1.0	98	54	83.8	62.0	72.9	+3.8	64.3	..	1.31	..	..	..	
Toronto . . . . .	1013.6	+1.3	91	47	81.3	56.9	69.1	+2.7	58.8	5.1	1.49	14	10.2	71	
Winnipeg . . . . .	1016.1	+2.5	79	47	71.4	53.8	62.6	+2.2	57.5	6.0	2.78	11	8.0	64	
St. John, N.B. . . . .	1017.9	+0.6	81	48	66.2	50.8	58.5	+1.6	42.4	0.85	0.13	6	11.7	52	
Victoria, B.O. . . . .	1017.9	+0.6	81	48	66.2	50.8	58.5	+1.6	42.4	0.85	0.13	6	11.7	75	

\* For Indian stations a rain day is a day on which 0.1 in. or more rain has fallen

